Screening For Environmental Concerns At Sites With Contaminated Soil and Groundwater

Volume 1: Summary Tier 1 Lookup Tables

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Executive Summary

This document presents Environmental Screening Levels (ESLs) for chemicals commonly found in soil and groundwater at sites where releases of hazardous chemicals have occurred. The ESLs replace screening levels presented in the previous edition of this document, entitled *Application of Risk-Based Screening Levels (RBSLs) And Decision Making to Sites With Impacted Soil and Groundwater* (December 2001). The change in terminology from "Risk-Based" screening levels to "Environmental" screening levels is intended to better convey the broad scope of the document and clarify that some screening levels are not "risk-based" in a strict toxicological definition of this term.

The ESLs are considered to be conservative. Under most circumstances, and within the limitations described, the presence of a chemical in soil, soil gas or groundwater at concentrations below the corresponding ESL can be assumed to not pose a significant, long-term (chronic) threat to human health and the environment. Additional evaluation will generally be necessary at sites where a chemical is present at concentrations above the corresponding ESL. Active remediation may or may not be required, however, depending on site-specific conditions and considerations. This document may especially be beneficial for use at sites with limited impacts, where the preparation of a more formal environmental assessment may not be warranted or feasible due to time and cost constraints.

The ESLs were developed to address environmental protection goals presented in the *Water Quality Control Plan for the San Francisco Bay Basin* ("Basin Plan," RWQCBSF 1995) of the San Francisco Bay Area Regional Water Quality Control Board (RWQCB). These goals include:

Surface Water and Groundwater:
- Protection of drinking water resources;
- Protection of aquatic habitats;
- Protection against adverse nuisance conditions.

Soil:
- Protection of human health;
- Protection of groundwater;
- Protection of terrestrial biota;
- Protection against adverse nuisance conditions.

The ESLs are presented in a series of four lookup tables. Each table reflects a specific combination of soil, groundwater and land-use characteristics that strongly influence the magnitude of environmental concerns at a given site. This allows the user to select ESLs that are most applicable to a given site.

The ESL document presents a "tiered" approach to environmental risk assessments. Under "Tier 1", sample data are directly compared to ESLs selected for the site and decisions are made regarding the need for additional site investigation, remedial action or a more detailed risk assessment. In a "Tier 2" risk assessment, a selected component(s) of the Tier 1 ESL is modified with respect to site-specific considerations. An example may be the adjustment of a screening level for direct exposure with respect to an approved, alternative target risk level. Site data are then compared to the revised screening level as well as the remaining, unmodified components of the Tier 1 ESL. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific risk assessments. Risk assessment models and assumptions that depart significantly depart from those used to develop the Tier 1 ESLs are described in a more traditional, "Tier 3" risk assessment. The Tier 1 methodology can, however, still provide a common platform to initiate a Tier 3 risk assessment and help ensure that all potentially significant environmental concerns are considered.

The Tier 1 ESLs presented in the lookup tables are NOT regulatory "cleanup standards". Use of the ESLs and this document in general is intended to be entirely optional on the part of the regulated facility and subject to the approval of the case manager in the overseeing regulatory agency. The presence of a chemical at concentrations in excess of an ESL does not necessarily indicate that adverse impacts to human health or the environment are occurring; this simply indicates that a potential for adverse risk may exist and that additional evaluation is warranted. ESLs presented for chemicals that are known to be highly biodegradable in the environment may in particular be overly conservative for use as final cleanup levels (e.g., many petroleum-related compounds). Use of the ESLs as cleanup levels should be evaluated in view of the overall site investigation results and the cost/benefit of performing a more site-specific risk assessment.

Reliance on only the Tier 1 ESLs to identify potential environmental concerns may not be appropriate for some sites. Examples include sites that require a detailed discussion of potential risks to human health, sites where physical conditions differ drastically from those assumed in development of the ESLs (e.g., mine sites, landfills, etc., with excessively high or low pH) and sites where impacts pose heightened threats to sensitive ecological habitats. The latter could include sites that are adjacent to wetlands, streams, rivers, lakes, ponds or marine shoreline or sites that otherwise contain or border areas where protected or endangered species may be present. Potential impacts to sediment are also not addressed. (e.g., presence of endangered or protected species). The need for a detailed ecological risk assessment should be evaluated on a site-by-site basis for areas where significant concerns may exist. Notification to the Natural Resource Trustee Agencies (including the state Department of Toxics Substances Control and Department of Fish and Game and the federal Fish and Wildlife Service, Department of the Interior and National Oceanic and Atmospheric Administration) may also be required, particularly if the release of a hazardous substance may impact surface waters.

The ESLs should NOT be used to determine when impacts at a site should be reported to a regulatory agency. All releases of hazardous substances to the environment should be reported to the appropriate regulatory agency in accordance with governing regulations. The lookup tables will be updated on a regular basis, as needed, in order to reflect changes in the referenced sources as well as lessons gained from site investigations and field observations.

1

Introduction

1.1 Purpose

Preparation of detailed environmental risk assessments for sites impacted by releases of hazardous chemicals can be a time consuming and costly effort that requires expertise in a multiple of disciplines, including toxicology, geology, ecology, chemistry, physics and engineering, among others. For small-business owners and property owners with limited financial resources, preparation of such risk assessments can be time and cost-prohibitive.

As a means to partially address this problem, this document presents a series of conservative Environmental Screening Levels (ESLs) for soil, groundwater and soil gas that can be directly compared to environmental data collected at a site. Correlative screening levels for surface water are also provided. Screening levels for over 100 commonly detected contaminants are given in a series of "lookup" tables. The tables are arranged in a format that allows the user to take into account site-specific factors that help define environmental concerns at a given property.

Within noted limits, risks to human health and the environment can be considered to be insignificant at sites where concentrations of chemicals of concern do not exceed the respective ESLs. The presence of chemicals at concentrations above the ESLs does not necessarily indicate that a significant risk exists at the site. It does, however, generally indicate that additional investigation and evaluation of potential environmental concerns is warranted.

The introductory text of this document is kept intentionally brief with a focus on theh use of the ERLs rather than technical details about their derivation. The latter is provided in the appendices of Volume 2.

1.2 Tiered Approach to Environmental Risk Assessments

This document presents a three-tiered approach to environmental risk assessment. Under "Tier 1", sample data are directly compared to ESLs selected for the site and decisions are made regarding the need for additional site investigation, remedial action or a more

detailed risk assessment. A detailed understanding of the derivation of the screening levels is not required for use at this level.

Under "Tier 2", selected components of the models used to develop the Tier 1 ESLs are modified with respect to site-specific data or considerations. Examples include adjustment of the assumed depth to impacted groundwater in the Tier 1 indoor-air impact model or use of an approved, alternative target risk level for direct-exposure concerns. Site data are then compared to the revised screening level as well as the remaining, unmodified components of the Tier 1 ESLs. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific risk assessments.

Under Tier 3, the user employs alternative models and modeling assumptions to develop site-specific screening or final cleanup levels or quantitatively evaluate the actual risk posed to human and/or ecological receptors by the impacted media. Consideration of the methodologies and potential environmental concerns discussed in this document is still encouraged, however. This will help increase the comprehensiveness and consistency of Tier 3 risk assessments as well as expedite their preparation and review.

1.3 Comparison To Existing Screening Levels

Both Region IX of the U.S. Environmental Protection Agency (USEPA 2002) and the City of Oakland (Oakland 2000) have prepared lookup tables of Environmental Screening Levels for soil and water. The lookup tables presented in this document represent an expansion of this work to reflect the broader scope of environmental concerns put forth in the Regional Water Quality Control Board (RWQCB) Basin Plan (RWQCBSF 1995). Differences and similarities between the ESL document and lookup tables prepared by the other programs are summarized below.

1.3.1 USEPA Region IX PRGs

The U.S. Environmental Protection Agency (USEPA) Region IX "Preliminary Remediation Goals" or "PRGs" are intended to address human health concerns regarding direct exposure with impacted soils (USEPA 2002). The equations used to develop the USEPA PRGs are generally consistent with human health risk assessment guidance prepared by the Department of Toxic Substances Control, including the CalTOX model (CalEPA 1994a) and the documents *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b) and *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a). As noted in Chapter 3, use of the CalTOX model and other CalEPA guidance documents and models may be necessary where more detailed risk assessments are required.

As discussed in the USEPA Region IX document, the PRGs are intended to address human direct-exposure with impacted soil and "...do not consider impact to groundwater or address ecological concerns." (USEPA 2002). Expansion of the USEPA PRGs in the lookup tables presented in this document includes:

- Modification of soil PRGs to reflect CalEPA-specific toxicity factors;
- Adjustment of PRGs for noncarcinogens to reflect a target hazard quotient of 0.2 to address potential cumulative health concerns;
- Addition of direct-exposure screening levels for construction and trench workers' exposure to subsurface soils;
- Addition of soil and groundwater screening levels for indoor-air impact concerns;
- Addition of groundwater screening levels for the protection of aquatic habitats/surface water quality;
- Use of a more rigorous leaching model to develop soil screening levels for protection of groundwater quality;
- Addition of soil screening levels for urban area, ecological concerns;
- Addition of soil and groundwater "ceiling levels" to address gross contamination and general resource degradation concerns; and
- Addition of soil and groundwater screening levels for Total Petroleum Hydrocarbons (TPH).

Use of the USEPA Region IX PRGs in the RWQCB lookup tables is discussed further in Section 3.2 of Appendix 1. A copy of the PRG background document is provided in Appendix 2.

1.3.2 City of Oakland Screening Levels

A brief comparison of the RWQCB and the City of Oakland approaches to the development of environmental screening levels is provided in Table 1-1. Since 1999, the City of Oakland has presented environmental screening levels for soil and groundwater through its Urban Land Redevelopment (ULR) Program. The ULR Program is a collaborative effort by the City of Oakland and the principal agencies charged with enforcing environmental regulations in Oakland to facilitate the cleanup and redevelopment of contaminated properties (Oakland 2000). It includes innovative institutional mechanisms for tracking residual contamination and ensuring long-term compliance with risk management plans. The ULR Program is coordinated by the City and is specific to Oakland sites.

The City of Oakland approach is based on the guidelines prescribed in *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM 1995). The Guidance Document, Technical Background Document and other information on the Oakland ULR program is available on the internet at www.oaklandpw.com/ulrprogram. Modifications have been made to better address child exposure and recreational water use scenarios. In addition, many input values reflect Oakland-specific geologic, hydrogeologic and climatic conditions (Oakland Technical Background 2000 and

updates). These values may not be appropriate for other areas within the RWQCB's jurisdiction.

The RWQCB has agreed that the Oakland look-up tables are appropriate for use at Oakland sites under the conditions and limitations discussed in the ULR Program Guidance (memo dated August 3, 2001; RWQCBSF 2001b). In particular, sites where surface or groundwater conditions present ecological, aesthetic, taste or odor concerns may require additional analysis. Active remediation to address these concerns may not be necessary at most sites in Oakland that are not near sensitive water bodies, however, due to its highly-developed, urban setting

1.3.3 Hazardous Waste Regulations

California Total Threshold Limit Concentrations (TTLC) criteria for solids and Soluble Threshold Limit Concentration (STLC) criteria for liquids should not in most cases be used as soil and groundwater screening or cleanup levels. The TTLC and STLC criteria are intended to determine the type of landfill a waste material must be sent to (Title 22, Section 66699 - Persistent and Bioaccumulative Toxic Waste). Where TTLC or STLC criteria are exceeded, the waste must in general be sent to a Class I, hazardous waste landfill. The criteria, developed in the 1980s, are only loosely based on human health and environmental considerations. STLC values in general reflect drinking water or surface water goals of the time, although some are clearly out-of-date (e.g. trichloroethylene STLC value of 204 mg/L). TTLC values were derived by simply multiplying the STLC value by ten (organic substances) or one hundred (metals).

In most cases, TTLC values exceed the most conservative environmental screening levels presented in this document. In the case of Endrin and DDT/DDE/DDD, however, the TTLC is somewhat lower than the screening levels for human health concerns. For example, the TTLC for combined DDT/DDE/DDD is 1.0 mg/kg while the residential, direct-exposure soil screening is 1.7 mg/kg. This presents the enigma that while soil impacted below 1.7 mg/kg is not considered to pose a significant risk to human health, it could be classified as a "hazardous waste" if it were excavated and transported offsite for disposal. Again, this is not a difference of opinion about the potential toxic effects of these chemicals, it is merely a reflection of the less rigorous development of the TTLC values.

Unfortunately, it is not anticipated that the TTLC and STLC values will be revised in the near future. To avoid potential future problems with soil disposal and even public perception, it may be prudent to use TTLCs as final cleanup values for sites where the TTLC is less than cleanup values based on actual risk to human health and the environment.

1.3.4 OSHA Standards Permissible Exposure Levels

The National Institute for Occupational Safety and Health (NIOSH) is the Federal agency responsible for conducting research and making recommendations for the prevention of work-related disease and injury, including exposure to hazardous chemicals in air (NIOSH 2003). NIOSH develops and periodically revises Recommended Exposure Limits (RELs) for hazardous substances in the workplace. The RELs are used to promulgate Permissible Exposure Levels (PELs) under the Occupational Safety and Health Act (OSHA).

OSHA Permissible Exposure Levels (PELs) for indoor air are intended for use in controlled, industrial work areas where employees are aware of potential health hazards associated with the chemicals they are using and are trained to take proper precautions and minimize exposure (NIOSH 2003). OSHA PELs are **not** appropriate for use at commercial/industrial sites where the chemical is not currently being used. This includes sites affected by the migration of offsite releases (e.g., via emissions from a moving plume of contaminated groundwater). Indoor-air protection goals for these sites should be based on long-term (chronic) health risk to workers. Such risk-based goals levels are typically much more stringent than OSHA PELs.

For example, the current OSHA PEL for trichloroethylene (TCE) is 678,000 ug/m^3 (100 ppmv, NIOSH 2003). Comparable risk-based screening levels for uncontrolled, commercial/industrial settings included in this document fall between 2.0 ug/m^3 and 10 ug/m^3 (carcinogenic effects vs noncarcinogenic effects, respectively; refer to Table E and Appendix 1, Table E-3). The PEL is applicable to work areas where TCE is being used and the employees have been properly trained to minimize exposure. The risk-based goals are applicable to all other areas.

1.3.5 RWQCB Basin Plan

The RWQCB Basin Plan ("Basin Plan") presents generic soil screening levels of 1.0 mg/kg total volatile organic compounds (VOCs) and 10 mg/kg semi-volatile organic compounds (SVOCs, RWQCBSF 1995). The Basin Plan states that the need to develop chemical-specific screening is to be evaluated on a site-by-site basis. As can be inferred from the detailed ESLs provided in Appendix 1, the Basin Plan screening level for total VOCs is probably adequate to overly conservative for gasoline-range petroleum fuel mixtures at most sites. Chemical-specific ESLs for benzene and MTBE are less than 1 mg/kg, due to their human toxicity and/or mobility in soil. The prevalence of less toxic and mobile VOCs in gasoline-range fuel mixtures (e.g., toluene, ethylbenzene, xylenes, etc.), however, would generally ensure that a total VOC screening level of 1 mg/kg adequately addresses concerns regarding these compounds in the absence of chemical-specific ESLs. The total VOC screening level is in all likelihood overly conservative for

most heavier fuel mixtures that lack significant amounts of benzene and MTBE (e.g., diesel fuel).

For direct-exposure, human health concerns, the Basin Plan screening level of 1 mg/kg for total VOCs as presented in the Basin Plan is adequate to marginally over-conservative for the most commonly detected chlorinated solvents (e.g., tetrachloroethylene, trichloroethane, trichloroethylene, etc.). From a modeling perspective, the screening level may be somewhat under-conservative for potential leaching and groundwater protection concerns (e.g., see Appendix 1, Table G). The model used to generate screening levels for leaching of chemicals from soil conservatively assumes, however, that the impacted soil was situated within one meter of groundwater. At the vast majority of sites where this is the actual case, groundwater has already been impacted by the main mass of chemicals and direct monitoring provides a more accurate evaluation of leaching impacts. For sites where impacted soil is situated greater than 10 meters from groundwater, model-generated screening levels developed by other agencies suggest that a screening level of 1 mg/kg (or more) may be adequate for chlorinated VOCs (e.g., HIDOH 1995).

The Basin Plan screening level of 10 mg/kg for total semi-volatile organic compounds (SVOCs) is probably overly conservative for these compounds for groundwater protection purposes. For soils impacted with carcinogenic SVOCs, the Basin Plan screening level has traditionally been used in conjunction with human-health screening levels presented in the USEPA PRGs. The PRGs are also referenced in this document although with some modifications.

The Basin Plan references a total petroleum hydrocarbon (TPH) soil screening level of 100 mg/kg for the protection of drinking water resources. A similar screening level was developed for use in this document. As noted in the lookup tables and discussed in Appendix 1, however, this screening level is considered to be overly conservative for heavy, residual fuels (fuel oil #6, motor oil, etc.) as well as for use at sites that do not pose a direct threat to drinking water or surface water resources.

1.4 Chemicals Not Listed In Lookup Tables

The lookup tables list 100-plus chemicals most commonly found at sites with impacted soil or groundwater. Inclusion of ESLs for additional chemicals is a relatively straightforward process, provided that adequate supporting data are available. To obtain ESLs for chemicals not listed in the lookup tables, the interested party should contact the RWQCB staff noted at the beginning of this document. Development of ESLs will be carried out in the same manner as done for the listed chemicals. As an alternative, ESLs may be developed by qualified persons and submitted to the overseeing regulatory agency for review (refer to Section 3.0).

1.5 Limitations

The Tier 1 ESLs presented in the lookup tables are NOT required, regulatory "cleanup standards". Use of the ESLs as actual cleanup levels should be evaluated in view of the overall site investigation results and the cost/benefit of performing a more detailed environmental risk assessment. The ESLs are intended to be conservative for use at the vast majority of impacted sites in developed areas. As discussed in Chapter 3, however, use of the Environmental Screening Levels may not be appropriate for final assessment of all sites. Examples include:

- Sites that have a high public profile and warrant a detailed, fully documented environmental risk assessment;

- Sites with less than 3.0m (ten feet) of low permeability soils (clay, silt, etc.) between impacted groundwater and the ground surface (including potential downgradient areas; applies only to use of groundwater screening levels for sites with low permeability, vadose-zone soils);

- Sites with high rainfall and subsequent high surface water infiltration rates (i.e., infiltration >28 inches (720mm) per year),

- Sites where inorganic chemicals (e.g., metals) are potentially mobile in leachate due to soil or groundwater conditions different than those assumed in development of the lookup tables (e.g., low pH at mine sites);

- Conservation areas where impacts pose heightened threats to ecological habitats (e.g., presence of endangered or protected species); and

- Sites where more than three known or suspected carcinogens or more than five chemicals with similar noncarcinogenic health effects have been identified.

- Sites affected by tides, rivers, streams, etc. where there is a potential for erosion and concentration of contaminants in aquatic habitats.

Examples of other site characteristics that may warrant a more detailed environmental risk assessment are discussed in Chapter 3 (refer also to discussion of screening levels in Appendix 1). In such cases, the information provided in this document may still be useful for identification of potential environmental concerns and development of strategies for preparation of a more site-specific risk assessment.

ESLs for chemicals that are known to be highly biodegradable in the environment may in particular be overly conservative for use as final cleanup levels. For example, final soil

ESLs for Total Petroleum Hydrocarbon (TPH) and many noncarcinogenic, petroleum-related compounds (e.g., xylenes) are driven by the protection of groundwater quality. If long-term monitoring demonstrates that actual impacts to groundwater are insignificant then less stringent soil (and groundwater) screening levels may be warranted. Additional guidance regarding the management of impacted soil and groundwater at petroleum-release sites is provided in the following documents (refer also to overseeing regulatory agency):

- *Interim Guidance on Required Cleanup at Low-Risk Fuel Sites* (RWQCBSF 1996);
- Guidelines for Investigation and Cleanup of MTBE and Other Ether-Based Oxygenates (SWRCB 2000).

Copies of these documents can be obtained from the RWQCB.

Soil ESLs do not consider potential water- or wind-related erosion and deposition of contaminants in a sensitive ecological habitat. This may especially be of concern for metals and pesticides that are only moderately toxic to humans but highly toxic to aquatic and terrestrial biota (e.g., copper). The RWQCB *Erosion and Sediment Control Field Manual* provides practical information on the mitigation of erosion and runoff concerns.

It is conceivable that soil, groundwater and soil gas screening levels for the emission of chlorinated, volatile organic compounds to indoor air concerns may not be adequately conservative in some cases. This is most likely to occur at sites where the vapor permeability of vadose-zone soils is exceptionally high (e.g., highly fractured bedrock, gravels, etc.) and/or where building designs, ventilation systems and local environmental conditions otherwise lead to higher-than-expected vapor flow rates through foundations (e.g., houses with heating systems in basements). As discussed in Appendix 1, conservative target risks are used in part to address these uncertainties.

Table 1-1. Comparison of RWQCB and Oakland Risk-Based Approaches

		RWQCB	[1]Oakland
General Approach	Tiers	One tier of look-up tables. Includes separate screening levels for indoor air concerns based on soil type.	Two tiers of look-up tables: Tier 1 table applicable at any Oakland site; Tier 2 tables (3) account for site-specific soil types (Merritt Sands, sandy silts, and clayey silts) and alternate target risk. Tier 3 spreadsheets provided.
	Target Cancer Risk Level	10^{-6}	10^{-6} for Tier 1; 10^{-5} for Tier 2.
	Target Noncancer Hazard Quotient	0.2 (with option for site specific adjustment)	1.0 (with requirement to address cumulative risk as necessary)
	Ceiling/Nuisance Levels	"Ceiling levels" to address gross contamination concerns, nuisances, free-product mobility, and general resource quality	No "ceiling levels"; recommends removal of mobile or potentially-mobile free product.
	Total Petroleum Hydrocarbons	Screening levels for TPH included	No TPH screening levels.
Soil Pathways	Definition of "Shallow" Soils	0-3 meters below ground surface.	0-1 meter below ground surface.
	Direct Exposure, Inhalation of Volatiles	USEPA PRG model (USEPA 2002). Assumes "infinite" source thickness for volatile organic compounds.	ASTM (1995) model. Assumes infinite source unless mass balance conditions violated based on 1.0 m thick source.
	Ecological Concerns	Screening levels for terrestrial biota included (shallow soils only).	Recommends site-specific analysis when significant ecological habitats are threatened.
	Deep Soils	Direct-exposure soil screening levels for Construction/ Trench Worker exposure scenario.	No screening levels for this scenario; recommends a site-specific analysis as warranted.
Groundwater	Leaching Model	Employs the SESOIL model.	Employs the ASTM (1995) model.
	Leaching of Inorganic Compounds	No soil screening levels; recommends laboratory tests.	Soil screening levels for inorganic compounds, based on a neutral pH.
	Surface Water Protection	Groundwater screening levels for the ecological and aesthetic protection of surface water.	Screening levels for recreational use of groundwater and surface water. Recommends site-specific analysis of ecological and aesthetic concerns as warranted.
Indoor Air	Thickness of Soil Source	Assumes five meters. Recommends site-specific analysis as warranted.	Assumes "infinite" source thickness.
	Convective Flow	Incorporates convective flow in indoor-air impact model.	Does not incorporate convective flow (i.e., assumes no pressure differential) in indoor-air impact model.
	Surface Soil Screening Levels	Includes screening levels for protection of indoor air for both surface and subsurface soils.	Recommends site-specific analysis and controls for shallow soils (<1m) and use of screening levels for deeper soils.
	Soil Gas	Includes screening levels for soil gas.	Not included.

1. *Oakland Risk-Based Corrective Action: Technical Background Document: City of Oakland, Environmental Services Division,* January 2000 (and updates), www.oaklanddpw.com/urlprogram.

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Tier 1 Lookup Tables

2.1 Organization of Lookup Tables

Environmental risk assessments may be carried out in either a "forward" mode, where actual risks are quantified based on concentrations of a chemical in an impacted media, or "backward" mode, where acceptable concentrations of a chemical in a given media are developed based on specified, target goals. The Environmental Screening Levels (ESLs) presented in this document represents an example of the latter. Tier 1 ESLs for soil and groundwater are summarized in Tables A through E. Each ESL in the tables collectively addresses environmental concerns stated or inferred in the *Water Quality Control Plan for the San Francisco Bay Basin* ("Basin Plan," RWQCBSF 1995), prepared by the San Francisco Bay Area Regional Water Quality Control Board (RWQCB). These concerns include:

Groundwater Quality:
- Protection of human health
  - Current or potential drinking water resource;
  - Emission of subsurface vapors to building interiors;
- Protection of aquatic habitats (discharges to surface water);
- Protection against nuisance concerns (odors, etc.) and general resource degradation.

Soil Quality:
- Protection of human health
  - Direct/indirect exposure to impacted soil (ingestion, dermal absorption, inhalation of vapors and dust in outdoor air);
  - Emission of subsurface vapors to building interiors;
- Protection of groundwater quality (leaching of chemicals from soil);
- Protection of terrestrial (nonhuman) habitats;
- Protection against nuisance concerns (odors, etc.) and general resource degradation.

Shallow Soil Gas:
- Protection of human health
  - Emission of subsurface vapors to building interiors.

For the purpose of this document, "soil" refers to any unlithified material in the vadose zone that is situated above the capillary fringe of the shallowest saturated unit. A

summary of environmental concerns considered in the ESLs is depicted schematically in Figure 1. This is correlative to a "conceptual site model" prepared for a detailed environmental risk assessment. The degree to which any given concern will "drive" environmental risk at a site depends on the actual potential for exposure and the toxicity and mobility of the chemical.

Site characteristics that play an important role in evaluating potential environmental concerns or developing site-specific cleanup levels include:

- Physical location of the impacted soil (e.g., currently or potentially exposed at the ground surface versus isolated in the subsurface);
- Beneficial use of the groundwater immediately underlying the site or otherwise potentially threatened by the release (e.g., drinking water resource threatened versus no drinking water resource threatened);
- Current and anticipated future use of the site (e.g., residential land use permitted or commercial/industrial land use only).

In order to include consideration of these site characteristics in the ESLs, four different tables were prepared (Tables A through D). Each table reflects varying combinations of site characteristics:

- Table A – Shallow soils, potential drinking water resource threatened;
- Table B – Shallow soils, potential drinking water resource not threatened;
- Table C – Deep soils, potential drinking water resource threatened;
- Table D – Deep soils, potential drinking water resource not threatened;

Each of the tables provides separate soil screening levels for residential (i.e., unrestricted) and commercial/industrial land-use scenarios.

For each chemical listed in the lookup tables, screening levels were selected to address each applicable environmental concern under the specified combination of site characteristics. The lowest of the individual screening levels for each concern was selected for inclusion in the summary Tier ESL tables presented in Volume 1 of this document. This ensures that the ESLs presented in these tables are protective of all potential environmental concerns and provides a tool for rapid screening of site data. Where ESLs are exceeded, the detailed tables provided in Appendix 1 can be used to identify the specific environmental concerns that may be present at the site.

An example of the selection of summary, Tier 1 ESLs for tetrachloroethylene (PCE) is presented in Figure 2 (surface soils, drinking water resource threatened, unrestricted land use desired). A more detailed discussion of this example is provided in Appendix 1.

2.2 Use of Lookup Tables

The step-by-step use of the lookup tables is summarized below and discussed in more detail in the following sections. A summary of the process is also provided in Figure 3. An outline and discussion of information that should be included in a Tier 1 environmental risk assessment is provided in Section 2.11.

Step 1 - ESL Updates and Applicability
Check with the overseeing regulatory agency to determine if the ESLs can be applied to the subject site. Ensure that the most up-to-date version of this document is being used (updated every 1-2 years in general).

Step 2: Identify All Chemicals of Potential Concern
An environmental risk assessment must be based on the results of a thorough site investigation, where all chemicals of potential concern have been identified. A summary of the site investigation results should be included in the risk assessment in order for it to be reviewed as a "stand alone" document." A general outline of site investigation information that should be included in a Tier 1 risk assessment is provided in Section 2.11.

Step 3: Select Lookup Table(s)
Determine the designated beneficial use of impacted or threatened groundwater beneath the site. In general, all groundwater must initially be treated as a current or potential source of drinking water (see Section 2.3). Next, determine the depth below ground surface to the top of impacted soil (see Section 2.4). This site information is then used to select the most appropriate lookup table (see Figure 3).

Steps 4: Determine Desired Land Use (soil ESLs only)
ESLs for soil are selected based on the present and desired future use of the site. Two options are provided in the lookup tables, "Unrestricted Land Use Permitted" or "Commercial/Industrial Land Use Only". Screening levels for unrestricted land used are considered to be adequate for residential use of a property. **For evaluation of commercial/industrial properties, it is highly recommended that site data be compared to ESLs for both unrestricted/residential and commercial/industrial land use.** Reference only to ESLs for commercial/industrial land use will in most cases require that a covenant to the deed be prepared that restricts use of the property to these purposes only (see Section 2.9).

Steps 5 and 6: Select Soil and/or Groundwater ESLs

Based on the desired land use(s), select appropriate soil ESLs. ESLs for groundwater are provided in the adjacent column of each table and are not dependent on land use or depth to impacted soil. Correlative screening levels for surface water are also provided. Replace ESLs with naturally occurring, background concentrations of chemicals of concern (e.g., arsenic) or laboratory method reporting levels if higher (see Section 2.8).

Step 7: Determine Extent of Impacted Soil and/or Groundwater

Using the selected ESLs, determine the extent of impacted soil or groundwater and areas of potential environmental concern at the site and offsite, as required. Soil data should be reported on a dry-weight basis (see Appendix 1, Section 6.2). For sites where sample data are limited, it will be most appropriate to compare the maximum-detected concentrations of chemicals of concern to the ESLs. For sites where an adequate number of data points are available, the use of statistical methods to estimate more site-specific exposure point concentrations and evaluate environmental risks may be appropriate. The exposure point concentration is generally selected as the lesser of the maximum-detected concentration and the 95% upper confidence interval of the arithmetic mean of sample data. Guidance for the estimation of exposure point concentrations, use of "non-detect" data, and other issues is provided in the CalEPA documents *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b) and *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a), among other sources. As discussed in these documents, sample data collected outside of impacted areas should generally not be included in estimation of exposure point concentrations. **For residential land use scenarios, sample data should be averaged over no more than a 1,000 ft^2 area**.

Steps 8 and 9: Evaluate The Need For Additional Investigation or Corrective Actions; Submit Appropriate Reports

Based on a comparison of available site data to the ESLs, evaluate the need for additional action at the site (e.g. additional site investigation, remedial action, preparation of a more site-specific risk assessment, etc.). This is then summarized in the Tier 1 Environmental Risk Assessment report and workplans for additional corrective actions as needed (see Section 2.11). Decisions for or against additional actions should always be made in conjunction with guidance from the overseeing regulatory agency.

Note that impacts to soil and water from petroleum mixtures are evaluated in terms of both Total Petroleum Hydrocarbon (TPH) and target "indicator chemicals" for the given petroleum mixture. Indicator chemicals typically recommended for petroleum mixtures include (after CalEPA 1996a):

Monocyclic Aromatic Compounds (primarily gasolines and middle distillates)

- benzene
- ethylbenzene
- toluene

- xylene

Fuel additives (primarily gasolines)
- MTBE
- other oxygenates as necessary

Polycyclic Aromatic Compounds (primarily middle distillates and residual fuels)
- methylnaphthalene (1- and 2-)
- acenaphthene
- acenaphthylene
- anthracene
- benzo(a)anthracene
- benzo(b)fluoranthene
- benzo(g,h,i)perylene
- benzo(a)pyrene
- benzo(k)fluoranthene
- chrysene
- dibenzo(a,h)anthracene
- fluoranthene
- fluorene
- indeno(1,2,3)pyrene
- naphthalene
- phenanthrene
- pyrene

The TPH ESLs should be used in conjunction with ESLs for these chemicals. As discussed in Appendix 1, the "middle distillates" category of TPH includes diesel fuel kerosene, stoddard solvent, home heating fuel, jet fuel and similar petroleum mixtures. "Residual fuels" includes heavy petroleum products such as No. 6 fuel oil ("Bunker C"), lubricating oils, "waste oils" and asphalts. Soil and groundwater impacted by releases of waste oil may also require testing for heavy metals and chemicals such as chlorinated solvents and PCBs. Screening levels for these chemicals are included in the lookup tables.

2.3 Groundwater Beneficial Use

As stated in the San Francisco Bay Region *Water Quality Control Plan* ("Basin Plan", RWQCBSF 1995), "Unless otherwise designated by the Regional Board, all groundwaters are considered suitable, or potentially suitable, for municipal or domestic water supply." All groundwater beneath a given site should be initially treated as a potential source of drinking water unless otherwise approved by the RWQCB office. For the purposes of this document, it is also assumed that all shallow groundwater will ultimately discharge to a body of surface water and potentially impact aquatic organisms (see Section 2.7). Soil and groundwater ESLs were therefore developed to be protective of both drinking water resources and aquatic habitats. This is discussed in greater detail in Chapters 2 and 3 of Appendix 1.

The Basin Plan recognizes that site-specific factors may render groundwater unsuitable for potential drinking water purposes. Tables B and D in this document are intended for use at such sites. The ESLs presented in these tables consider the potential discharge of groundwater to surface water but do not consider potential impacts to sources of drinking water. The ESLs also consider "gross contamination" issues such as the presence of free product and aesthetic or odor problems. Use of these tables for screening level environmental risk assessments must be approved by the RWQCB but may not necessarily require regulatory "de-designation" of groundwater beneficial use.

Hydrogeologic criteria presented in the Basin Plan for potential exclusion of a given occurrence of groundwater from consideration as a potential source of drinking water include:

- Total dissolved solids in groundwater is greater than or equal to 3,000 mg/L; OR

- Water bearing unit is not sufficiently permeable to produce an average, sustained yield of 200 gallons of water per day.

Groundwater in coastal areas, geothermal fields, etc., may contain levels of dissolved solids that make the water unsuitable as a potential source of drinking water. In addition, the permeability of soils and sediments that lack a significant amount of coarse-grained material (or fractures, in the case of bedrock) may be too low to allow for an adequate, sustained yield of groundwater. Unconsolidated geologic units that are comprised of less than 20% sand-size (or larger) material or more than 30% clay-size material are typically not considered to be viable "aquifers" or potential sources of useable groundwater (inferred from Fetter 1994). The potential for a given unit of bedrock to serve as a viable source of groundwater similarly depends on the primary and secondary porosity in the rock and the quality of the groundwater. Consideration must also be made for the potential migration of groundwater out of a geologic unit that in itself is insufficiently permeable to be considered to be an aquifer and into a more permeable unit that could serve as a viable source of drinking water.

In general, soil and groundwater screening levels are more stringent for sites that threaten a potential source of drinking water (e.g., compare Tables A and B). This is particularly true for chemicals that are highly mobile in the subsurface and easily leached from impacted soil. For chemicals that are especially toxic to aquatic life (e.g., several long-chain hydrocarbons, pesticides and heavy metals), however, screening levels for sites that threaten drinking water resources may be driven by surface water/aquatic habitat protection concerns. This is discussed in more detail in Appendix 1.

2.4 "Shallow" Versus "Deep" Soils

For the purposes of this document, a depth of three meters (approximately 10 feet) was used to delineate between "shallow" soils, where a potential exists for regular direct exposure of residents and/or office workers, and "deep" soils where only periodic exposure during construction and utility maintenance work is considered likely. This is consistent with guidance presented in the CalEPA document *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a) and is regarded as the maximum, likely depth that impacted soil could at some point in the future be excavated and left exposed at the surface during typical redevelopment activities. The potential for deeper soils to be brought to the surface in the future should be evaluated on a site-by-site basis based on planned redevelopment or maintenance activities.

The full suite of environmental concerns noted in Figure 1 was considered in development of ESLs for shallow soils. For deep soils, regular exposure of residents or commercial/industrial workers and impacts to terrestrial flora and fauna was not considered. As a result, ESLs for relatively non-mobile chemicals are generally less stringent for deep soils than correlative ESLs for shallow soils (e.g., compare PCB ESLs in Tables A and C). For chemicals that are easily leached from soil or potentially emitted to the air as a volatile gas, however, groundwater and indoor-air protection concerns usually drive selection of the final ESL regardless of the depth of the impacted soil. This is the case for several of the highly volatile, chlorinated organic compounds. As a result, correlative shallow and deep soil ESLs are identical (e.g., compare trichloroethylene ESLs in Tables A and C).

If impacted soil extends across the three-meter dividing line between shallow soil and deep soil, it may be appropriate to use a separate set of screening levels for each zone (e.g., Table A for the shallow soils and Table C for the deep soils). As discussed in Section 2.9, however, the pros and cons of remediating deep soils to shallow soil criteria should be evaluated on a site-by-site basis. This may help avoid concerns regarding future disturbance and reuse of deeper soils.

As another alternative, the less stringent ESLs for deep soils could be applied to shallower soils under a Tier 2 or Tier 3 risk assessment (refer to Chapter 3), provided that appropriate actions to prevent future exposure and unmanaged reuse are taken. Such controls may include (but not necessarily be limited to):

- placement and maintenance of adequate cap or other risk-management measures to eliminate potential direct exposure;
- modeling and/or direct field measurement to evaluate potential impacts to indoor air due to vapor emissions; and

- preparation of a risk management plan and other appropriate institutional controls (e.g., deed restrictions) in order to prevent unauthorized disturbance of the soil in the future and allow for appropriate management of the soil if it is exposed.

Capping of shallow, contaminated soil and other engineered controls used in place of full cleanup are generally not allowed for properties that are to be used for single-family homes. The need to consider these actions at sites with impacted soils situated more than three meters below the ground surface should be discussed with the overseeing regulatory agency on a site-by-site basis.

2.5 Land Use

Land uses are categorized based on the assumed length, duration and magnitude of potential human exposure. The category "Residential Land Use" is intended for use at sites where future land-use restrictions are not desirable or allowed. This includes sites to be used for residences, hospitals, day-care centers and other sensitive purposes (e.g., refer to DTSC 2002). ESLs listed under this category incorporate conservative assumptions regarding long-term, frequent exposure of children and adults to impacted soils in a residential setting (see Appendices 1, Section 3.2 and Appendix 2). In contrast, the land-use category "Commercial/Industrial Use Only" assumes that only working age adults will be present at the site on a regular basis. Direct-exposure assumptions incorporated into the soil ESLs are somewhat less conservative than assumptions used in the residential land-use scenario.

Land use should be selected with respect to the current and foreseeable future use of the site in question. Reference to adopted General Plan zoning maps and local redevelopment plans is an integral part of this process. Use of the lookup tables for sites with other land uses (e.g., agriculture, parkland, etc.) should be discussed with and approved by the overseeing regulatory agency. As the category heading implies, use of the soil ESLs listed under "Commercial/Industrial Use Only" places implicit land-use restrictions on the affected property. While this may be considered acceptable for properties currently zoned for such purposes, the need for such restrictions in the future should be seriously weighed against the cost-benefit of remediating the property to meet the sometimes more conservative but less restrictive ESLs for unrestricted land use. Implications for land-use restriction are discussed in more detail in Section 2.9.

A 2003 amendment to the Porter-Cologne Act (Section 13307.1(c)) requires that formal land-use restrictions be placed on sites that are not remediated to an extent that allows unrestricted future use (e.g., residential, day care, etc.). This rule does not currently apply to sites regulated under the state underground storage tank program. It is anticipated that this rule will be especially applied to non petroleum-impacted sites.

2.6 Threat To Surface Water Habitats

Screening levels for freshwater, marine and estuarine water bodies are presented in Table F. These screening levels consider the same set of environmental concerns as groundwater, with the addition of screening levels for the potential bioaccumulation of chemicals in aquatic organisms and subsequent human consumption of these organisms. Locally, the areas north of the Dumbarton Bridge and west of the Richmond-San Rafael Bridge are considered to be marine. The areas south of the Dumbarton Bridge and east of the Richmond-San Rafael Bridge to the upstream extent of tidal influences are considered to be estuarine. Tidally influenced portions of creeks, rivers and streams flowing into the Bay between these areas should also be considered to be estuarine in screening level assessments.

For the purposes of the Tier 1 lookup tables, it is assumed that impacted or potentially impacted groundwater at all sites could at some time migrate offsite and discharge into a body of surface water. This could occur due to the natural, downgradient migration of groundwater or to human activities such as dewatering of construction sites. For several pesticides and heavy metals, including dieldrin, endrin and endosulfan, aquatic habitat goals are more stringent than drinking water toxicity goals for humans. This is reflected in the final groundwater screening levels (refer also to Appendix 1).

The groundwater screening levels for potential impacts to aquatic habitats do not consider dilution of groundwater upon discharge to a body of surface water. Benthic flora and fauna communities situated below or at the groundwater/surface water interface are assumed to be exposed to the full concentration of chemicals in impacted groundwater. Use of a generic "dilution factor" to adjust the surface water protection screening levels with respect to dilution of groundwater upon discharge to surface water was therefore not considered. Consideration of dilution/attenuation factor and alternative groundwater screening levels for the protection of surface water quality may, however, be appropriate on a site-specific basis.

Consideration of surface water standards for bioaccumulation concerns in groundwater investigations and cleanup actions may be warranted at sites where large plumes of impacted groundwater threaten to cause long-term impacts to important aquatic habitats. The bioaccumulation standards will generally not need to be considered at sites with small, isolated plumes of impacted groundwater located some distance from a body of surface water. Although these plumes could conceivably migrate offsite and discharge into a body of surface water in the distant future, impacts are likely to be short-lived and the plumes are likely to become significantly diluted as they mix with surface water. The need for a more detailed study of potential groundwater impacts on surface water with respect to bioaccumulation of chemicals in aquatic organisms should be evaluated on a site-by-site basis. This may include the need for more stringent soil cleanup levels (to prevent additional leaching) and development of a more comprehensive, ecological risk assessment.

The soil and groundwater screening levels presented in the lookup tables do not directly address the protection of sediment quality. Site-specific concerns could include the accumulation and magnification of concentrations of highly sorptive chemicals in sediment over time due to long-term discharges of impacted groundwater. This may be especially true for groundwater impacted with highly sorptive (lipophyllic) chemicals, including heavy petroleum products.

Potential erosion and runoff of surface soils from impacted sites may also need to be considered, particularly at sites impacted with metals and pesticides that are situated near a sensitive body of surface water. The need for a more detailed, ecological risk assessment of impacts to sediment should be evaluated on a site-by-site basis and discussed with the overseeing regulatory agency.

2.7 Screening For Indoor-Air Impact Concerns

Volatile chemicals can be emitted from contaminated soil or groundwater and intrude overlying buildings, impacting the quality of indoor air. Heating systems, basements, and strong winds can exacerbate this problem by reducing the internal air pressure and creating a "vacuum effect" that enhances the advective flow of vapors out of the underlying soil and into the building. Additional information on subsurface vapor intrusion into buildings is provided in the USEPA document *User's Guide For The Johnson and Ettinger (1991) Model For Subsurface Vapor Intrusion Into Buildings* (USEPA 2000; refer also to Appendix 1).

The direct collection and analysis of indoor air samples would seem to be an easy way to evaluate this concern. Identification of the source of impacts is complicated, however, by the presence of the same chemicals in many household goods (aerosol sprays, dry-cleaned clothing, cleaners, etc.). In addition, plumes of groundwater impacted with volatile chemicals are known to extend over significant areas and comprehensive testing of every structure over the plume is not practical.

As an alternative, the comparison of site groundwater, soil gas and soil data to conservative screening levels for indoor air concerns is recommended. Screening levels incorporated into this document are based on scientific models for vapor intrusion into buildings as well as a growing body of data from actual field investigations. A detailed discussion of the screening levels is presented in Appendix 1. The following three-phase, sequential approach is recommended for initial evaluation of potential indoor-air impact concerns at sites where shallow groundwater has been impacted by volatile chemicals:

1) Compare groundwater data to appropriate screening levels for indoor air concerns (see Table E-1a of Appendix 1).

2) For areas over the plume where groundwater screening levels for indoor-air concerns are approached or exceeded, collect shallow soil gas samples under (preferred) or adjacent to buildings and compare results to soil-gas screening levels for this concern (refer to Table E in this volume or Table E-2 in Appendix 1).

3) At buildings soil-gas screening levels for indoor-air concerns are approached or exceeded, collect indoor-air samples and compare results to indoor-air screening levels (refer to Table E in this volume or Table E-3 in Appendix 1).

For sites where the vapor permeability of shallow soils has not been evaluated, screening levels for groundwater overlain by highly permeable vadose-zone soils should be used. Imported fill material or disturbed native soils should be considered to be highly permeable unless site-specific data indicates otherwise.

Unless inhibited by very high water tables or other obstacles, soil gas samples should be collected immediately beneath the foundations of existing buildings (e.g., "subslab" or in crawl spaces) or three to five feet below ground surface in open areas where buildings may be constructed in the future. Soil gas samples collected from depths less than three feet are currently considered unreliable due to the increased potential to draw in ambient, surface air. If site-specific modeling of vapor flow rates or indoor-air impacts is to be carried out, the collection of additional geotechnical data at the time soil gas samples are collected should be considered (soil grain-size analysis, moisture content, vapor permeability, etc.).

Soil screening levels for potential indoor-air concerns are incorporated into the summary tables of this volume and presented separately in Table E-1b of Appendix 1. At sites where minor releases of volatile chemicals have occurred (e.g., restricted spills around underground tank fill ports), direct comparison of soil screening levels to site data is generally acceptable. If screening levels are exceeded, a similar approach to that outlined above for impacted groundwater is recommended. The restricted size of soil samples and the difficulty in predicting vapor-phase concentrations of chemicals from soil data limits the use of this data as a stand-alone tool for evaluating indoor-air concerns. **At sites where significant releases of volatile chemicals have occurred, the direct use of soil gas data in conjunction with soil data is strongly recommended.**

Guidance on the collection of indoor air and soil gas samples is provided in the following documents, among other sources:

- *Indoor Air Sampling And Evaluation Guide* (2002): Massachusetts Department of Environmental Protection, Office of Research and Standards, WSC Policy #02-430; http://www.state.ma.us/dep/bwsc/finalpol.htm;

- *Soil Gas Advisory* (January 2003): Department of Toxic Substances Control and Los Angeles Regional Water Quality Control Board; http://www.dtsc.ca.gov/PolicyAndProcedures/SiteCleanup/SMBR_ADV_activesoilgasinvst.pdf.

Additional information on the intrusion of subsurface vapors into buildings will be incorporated into this document as available. Individuals are encouraged to provide comments and suggestions to the contacts listed in the front of this document at anytime.

2.8 Substitution of Laboratory Reporting Limits and Ambient Background Concentrations for ESLs

In cases where an ESL for a specific chemical is less than the laboratory method reporting limit for that chemical (as agreed upon by the overseeing regulatory agency), it is generally acceptable to consider the method reporting limit in place of the screening level. Potential examples include the soil health-based ESLs for dioxin (e.g., 0.0000045 mg/kg for residential exposure).

Background concentrations of metals in soils are presented in the summary lookup tables in cases where they exceed screening levels for human health and environmental concerns. This is particularly an issue for arsenic and thallium in Bay area soils. For example, typical mean background concentrations of arsenic in Bay area soils ranges from approximately 5 mg/kg to 20 mg/kg, with some soils containing up to 40+ mg/kg arsenic (LBNL 2002). These concentrations are well above the health-based, direct-exposure goals for arsenic in soil of 0.39 mg/kg (residential exposure) and 1.6 mg/kg (commercial/industrial exposure) presented in the appendices.

For use in this document, an assumed background level of 5.5 mg/kg arsenic was substituted for toxicity-based goals in the lookup table if higher than the later. A background concentration of 58 mg/kg total chromium in soil is also assumed in the lookup tables. Note that background levels of total chromium can be significantly higher (>1,000 mg/kg) in soils developed over mafic and ultramafic rocks in the Bay area. Refer also to Appendix 1, Section 3.2.4 for additional discussion of this issue.

Figure 4 suggests steps that could be taken when evaluating a site for potential arsenic impacts. The natural background concentration of a chemical in soil or groundwater can vary significantly between and even within sites and is most appropriately evaluated by the collection of on-site samples or by reference to local data collected from past studies. Guidance for estimating background concentrations of chemicals in soil and groundwater is provided in the CalEPA document *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a). Sources of background metal concentration in soils in California include the University of California-Riverside report *Background Concentrations of Trace and Major Elements in California Soils* (UCR 1996) and the Lawrence Berkeley

Laboratory document *Protocol for Determining Background Concentrations if Metals in Soil at Lawrence Berkeley National Laboratory* (LBNL 2002).

A similar approach should be taken for total chromium. Additional review of background total chromium concentrations in soil should be carried out at sites where the screening level of 58 mg/kg is exceeded. If reported levels of total chromium still appear to exceed anticipated site-specific background levels, then soil samples should be tested for Cr VI and Cr III. Data should be compared to screening levels for these specific species of chromium and action taken as needed.

2.9 Implied Land-Use Restrictions Under Tier 1

Allowing the option to tie screening levels or cleanup levels to site-specific land use and exposure conditions can save considerably in investigation and remediation costs. For example, the screening level for polychlorinated biphenyls (PCBs) in surface soils is 0.22 mg/kg in residential areas but up to 7.0 mg/kg (at target risk of 10^{-5}) for commercial/industrial areas. Even higher levels of PCBs could potentially be allowed to remain in place onsite provided that adequate controls to mitigate potential exposure are put into effect (e.g., permanent cap, protection of groundwater, etc.).

The use of final cleanup levels less stringent than those appropriate for unrestricted land use will, however, place restrictions on future use of the property. For example, if a site is remediated using ESLs (or alternative criteria) intended for commercial/industrial land use then the site cannot be used for residential purposes in the future without additional evaluation. In most cases, this will require that a formal covenant to the deed be recorded to restrict future use of the property. As stated in recent provisions in the Porter-Cologne Act (Section 13307.1(c)):

> "...if the state board or the regional board finds that the property is not suitable for unrestricted use...then the state board and regional boards may not issue a closure letter, or make a determination that no further action is required...unless a land restriction is recorded..."

The use of ESLs for deep soils at a site similarly assumes that the impacted soil will remain isolated below the ground surface "for eternity". For single-family, residential areas, future disturbance of soil situated greater than three meters is generally considered to be unlikely (CalEPA 1996a) and use of the ESLs for deep soil below this depth without restrictions may be reasonable (see Section 2.4). During the redevelopment of properties for commercial/industrial or high-density residential use, however, excavation and removal of soils from depths in excess of five or even ten meters could take place (e.g., for underground parking garages, elevator shafts, utilities, etc.). The need to impose enforceable, institutional controls for proper management of deep, impacted soils

at properties where the subsurface ESLs (or alternative cleanup levels) are applied should be discussed with the overseeing regulatory agency on a site-by-site basis.

Land-use restrictions inherent in the selection of ESLs from the Tier 1 lookup tables (or assumptions used in site-specific risk assessments) should be kept as minimal as possible. **Concentrations of chemicals in impacted soils left in place at a commercial/industrial site should always be compared to both commercial/industrial AND residential ESLs (or alternative criteria for unrestricted land use).** If the soils in fact meet ESLs for unrestricted land use after cleanup then this should be clearly stated in the site closure report. Recognizing this point may prove important should the site unexpectedly become desirable for other use in the future (e.g., residential, school day care, health care, etc.). **Assumptions that impacted soil at a property will remain isolated at shallow depths under pavement, buildings or some other type of "cap" should likewise be avoided if at all possible.** Such assumptions place significant and oftentimes unnecessary restrictions on the future use and redevelopment of a site. If done, appropriate covenants to the property deed should be prepared and methods to prevent or manage future disturbance of the soil should be clearly described and ensured. A foresighted approach in the use of Tier 1 ESLs or alternative, site-specific cleanup levels will allow more flexibility in future use of a site, help avoid unexpected complications during site redevelopment and minimize the liability of future land owners.

2.10 Cumulative Risks at Sites With Multiple Chemicals of Concern

Risks posed by direct exposure to multiple chemicals with similar health affects are considered to be additive or "cumulative." For example, the total risk of cancer posed by the presence of two carcinogenic chemicals in soil is the sum of the risk posed by each individual chemical. The same is true for chemicals that cause noncarcingenic health effects. A summary of example target health effects for the chemicals listed in the lookup tables is provided in Appendix 1 (Table L).

Use of ESLs for single chemicals is limited to the extent that the screening levels remain protective of human health should other chemicals with similar health effects also be present. Soil ESLs are considered to be adequate for use at sites where no more three carcinogenic chemicals or five chemicals with similar noncarcinogenic ("systemic") health effects are present. This is based on a combination of conservative exposure assumptions and target risk factors in direct-exposure models. Refer to Appendix 1, Section 1.3, for additional discussion of this subject.

2.11 Framework For a Tier 1 Environmental Risk Assessment

Tier 1 environmental risk assessments should serve as "stand alone" documents that provide a good summary of environment impacts at a site and assess the threats posed to human health and the environment by these impacts. The risk assessment can be prepared as a component of a site investigation or remedial action report or as a separate document. Information on each of the topics listed below should be addressed in report that presents the risk assessment, however (after MADEP 1995). Together, this information is intended to provide a basic "conceptual model" of site conditions. The level of detailed required for each topic will vary depending on site-specific considerations.

1. Summarize Past, Current and Anticipated Future Site Activities and Uses:
   - Describe past and current site uses and activities;
   - Describe foreseeable future site uses and activities. **(Always include a comparison of site data to ESLs for unrestricted land use to evaluate need for formal covenants to the deed; see Section 2.9).**
2. Summary of Site Investigation:
   - Identify all types of impacted media;
   - Identify all sources of chemical releases;
   - Identify all chemicals of concern;
   - Identify magnitude and extent of impacts that exceed ESLs to extent feasible and applicable (include maps of site with isoconcentration contours for soil and groundwater);
   - Identify nearby groundwater extraction wells, bodies of surface water and other potentially sensitive ecological habitats;
   - Ensure data are representative of site conditions.
3. Summarize Appropriateness of Use of Tier 1 Lookup Tables and ESLs (see Section 1.5):
   - Do Tier 1 ESLs exist for all chemicals of concern?
   - Does the site have a high public profile and warrant a fully documented, detailed environmental risk assessment?
   - Do soil and groundwater conditions at the site differ significantly from those assumed in development of the lookup tables (e.g., low pH at mine sites)?
   - Do impacts pose a heightened threat to sensitive ecological habitats (e.g., presence of endangered or protected species)?
   - Is the thickness of vadose-zone soils impacted by volatile organic compounds greater than three meters (10 feet, see Section 1.5 and Appendix 1);
   - Have more than three carcinogens or five chemicals with similar noncarcinogenic health effects been identified (see Section 2.10)?

- Other issues as applicable to the site.

4. Soil and Groundwater Categorization (see Sections 2.3 and 2.4):
   - State the regulatory beneficial use of impacted or potentially impacted groundwater beneath the site; discuss the actual, likely beneficial use of groundwater based on measured or assumed quality of the groundwater and the hydrogeologic nature of the soil or bedrock containing the groundwater.
   - Characterize the soil type(s) and location of impacted soil as applicable to the lookup tables (e.g., soil stratigraphy, soil texture and permeability, depth to and thickness of impacted soil, etc.).
5. Exposure Point Concentrations (see Section 2.2, Step 7):
   - Identify maximum concentrations of chemicals present in impacted media.
   - Describe how alternative exposure point concentrations were determined (e.g., 95% UCLs), if proposed, and provide supporting data. **For residential land use scenarios, sample data should be averaged over no more than a 1,000 ft^2 area.**
   - Discuss the need to evaluate groundwater data with respect to surface water standards for potential bioaccumulation of chemicals in aquatic organisms ("Elevated threat to surface water body"), due to the size of the plume, the proximity of the plume to a body of surface water and the potential for minimal dilution of groundwater upon discharge to surface water (see Section 2.7).
   - Discuss how background concentrations of chemicals were determined, if considered for use in the risk assessment (see Section 2.8).
6. Selection of Tier 1 ESLs and Comparison to Site Data (see Section 2.2)
   - Summarize how Tier 1 ESLs were selected with respect to the information provided above and additional assumptions as applicable.
   - Compare site data to the selected summary Tier 1 ESLs (presented in Volume 1) and discuss general results.
   - If desired or recommended, compare site data to detailed ESLs for individual environmental concerns (presented in Volume 2, Appendix 1) and discuss specific, potential environmental concerns present at site.
7. Conclusions (see Section 2.9):
   - Describe the extent of soil and groundwater impacts above Tier 1 ESLs, using maps and cross sections as necessary.
   - Discuss if a condition of potential risk to human health and the environment exists at the site.
   - Discuss if a more site-specific risk assessment is warranted at the site.
   - Present a summary of recommended future actions proposed to address environmental concerns ay the site.
   - Discuss the need to impose land-use restrictions and institutional controls at the site based on the results of the Tier 1 assessment (e.g., requirements for caps,

etc.; need for covenant to deed to restrict land use to commercial/industrial purposes only, etc).

The above list is not intended to be exhaustive or representative of an exact outline required for all Tier 1 risk assessments. Requirements for completion of an adequate site investigation and Tier 1 environmental risk assessment should be discussed with the overseeing regulatory agency.

3

Tier 2 and 3 Environmental Risk Assessments

3.1 Conditions Warranting More Detailed Risk Assessments

Use of the Tier 1 Environmental Screening Levels is optional and independent environmental risk assessments may be undertaken for any site. In some cases, site conditions may negate the full use of the Tier 1 ESLs and require preparation of a Tier 2 or Tier 3 risk assessment. Examples of site conditions that may warrant a more site-specific or detailed risk assessment include (see also Section 1.5):

- Sites where alternative target risk levels or chemical-specific toxicity factors may be acceptable to the regulatory agency (see Appendix 1, Sections 1.3 and 3.2);
- Sites where the thickness of vadose-zone soils impacted by volatile organic compounds is greater than three meters (soil screening levels for potential indoor air concerns may not be adequately conservative; see Appendix 1, Section 3.3);
- Sites where screening levels for soil are driven by potential leaching concerns and groundwater data are available for evaluating actual groundwater impacts (main mass of impacted soil should be in contact with groundwater; see Appendix 1, Section 3.4);
- Sites where inorganic chemicals (e.g., metals) cannot be assumed to be immobile in soil (potential threat to groundwater quality; see Appendix 1, Section 3.4);
- Sites with soils impacted by pesticides, where final screening levels are driven by leaching concerns and potential impacts to aquatic habitats but the site is not located near a body of surface water (e.g., dieldrin, endrin, endosulfan, etc.);
- Sites where the depth to groundwater is greater than ten meters below the base of impacted soil (soil screening levels for leaching concerns may be excessively conservative; see Appendix 1, Section 3.4);

- Sites where protected terrestrial habitats or other ecologically sensitive areas are threatened (soil ESLs may not be adequately conservative; see Appendix 1, Section 3.5);

- Sites where engineered controls will be implemented to eliminate or reduce specific exposure pathways (avoid whenever possible; see Section 2.9);

- Sites where the future erosion of shallow soils could lead to significant transport and concentration of contaminants in sensitive ecological habitats; and

- Sites where field observations or site conditions otherwise indicate that the ESLs may not be adequately conservative or may be excessively conservative.

Reliance on only the Tier 1 ESLs to identify potential environmental concerns may not be appropriate for some sites. Examples include sites that require a detailed discussion of potential risks to human health; sites where physical conditions differ drastically from those assumed in development of the ESLs (e.g., mine sites, landfills, etc., with excessively high or low pH) and sites where impacts pose heightened threats to sensitive ecological habitats. The latter could include sites that are adjacent to wetlands, streams, rivers, lakes, ponds or marine shoreline or sites that otherwise contain or border areas where protected or endangered species may be present. Potential impacts to sediment are also not addressed (e.g., presence of endangered or protected species). The need for a detailed ecological risk assessment should be evaluated on a site-by-site basis for areas where these concerns may be present (see Section 3.3.5). Notification to the Natural Resource Trustee Agencies (including the state Department of Toxics Substances Control and Department of Fish and Game and the federal Fish and Wildlife Service, Department of the Interior and National Oceanic and Atmospheric Administration) may also be required, particularly if the release of a hazardous substance may impact surface waters.

Evaluation of landfills and sites impacted by mine wastes may in particular require the preparation of a detailed, site-specific assessment of groundwater and surface water impact concerns due to the possible elevated mobility of metals and other chemicals. Soil leaching models incorporated into the Tier 1 ESLs assume typical, ambient physio-chemical conditions in soil and groundwater (e.g., soil pH 5.0 to 9.0) and the relatively immobility of heavy metals and organic chemicals with very high sorption factors (e.g., PCBs, PAHs, stc.). This assumption may not hold true at many landfill and mine sites, where extreme pH and Eh conditions could lead to substantial mobility of these compounds. In these and other related cases, more rigorous field and laboratory studies may be required to adequately assess risk to human health and the environment.

Final surface water and groundwater screening levels for several pesticides that are highly toxic to aquatic organisms are very stringent (e.g., dieldrin, endrin, endosulfan, etc.; refer to Tables A-D in this volume and Table F series in Appendix 1). Correlative soil screening levels for leaching concerns are likewise very stringent (refer to Table A-D series in Appendix 1). The pesticides in question are only moderately mobile in the environment. The final soil and groundwater screening levels are likely to be excessively

conservative for sites not located near a body of surface water. The need to apply the screening levels to soil and groundwater data should be evaluated on a site-by-site basis. Less conservative screening levels for evaluation of human-toxicity concerns only may be appropriate at many sites.

Site-specific risk assessments are grouped under the loosely defined terms "Tier 2" and "Tier 3". The nature of these risk assessments is briefly discussed below.

3.2 Tier 2 Environmental Risk Assessments

3.2.1 Purpose

Tier 2 environmental risk assessments are intended to be relatively easy and cost-effective to prepare. Preparation of Tier 2 risk assessments will require a thorough understanding of the Tier 1 ESLs being re-evaluated, however. Under Tier 2, specific Tier 1 screening levels are adjusted or deleted to more closely reflect site conditions or alternative risk assumptions. Replacing only targeted components of the Tier 1 ESLs reduces the need to prepare and justify an independent, detailed risk assessment when Tier 1 ESLs cannot or should not be fully applied. This greatly reduces the time and cost incurred by both the regulated business and the overseeing regulatory agency in finalizing the risk assessment.

For example, the Tier 1 screening level for leaching concerns may not need to be considered at sites where groundwater monitoring data indicate that leaching impacts from soil to groundwater are minimal or not posing an adverse risk. A common modification under Tier 2 may also include the adjustment of target risk level for carcinogens in soils at commercial/industrial sites from 10^{-6} to a cumulative risk of 10^{-5} or a cumulative hazard index of 1.0 (and likely preparation of a covenant to the deed that formally restricts land use). This could increase the direct-exposure screening levels for carcinogens by a factor of up to ten. In these examples, all other components of the Tier 1 ESLs are retained for use in the risk assessment. The modifications to Tier 1 assumptions are described and justified in the text of the report and the revised set of screening levels are presented.

3.2.2 Example Tier 2 Modifications of Tier 1 ESLs

A more detailed list of potential Tier 2 modifications to Tier 1 screening levels is presented below (refer also to Appendix 1). These examples are not intended to reflect the full range of modifications possible:

Groundwater Screening Levels

Drinking Water:

- Exclusion of drinking water impact concerns based on natural groundwater quality or geologic characteristics of groundwater containing unit (e.g., brackish groundwater in coastal areas);

Indoor Air Impacts:

- Use of site-specific data for model input parameters (depth to groundwater, soil properties, building characteristics, target risk or hazard index, etc.);
- Use of soil gas and/or indoor air data to more directly evaluate potential impacts;
- Use of alternative chemical toxicity factors or target risk levels;

Surface Water Impacts:

- Exclusive use of freshwater or saltwater screening levels;
- Consideration of alternative surface water screening levels;
- Consideration of groundwater monitoring data and observed plume migration over time;
- Consideration of site-specific dilution effects during potential discharge of groundwater to surface water (generally not recommended except in highly developed and disturbed water front properties);

Gross Contamination:

- Use of alternative ceiling levels and/or site-specific observations and considerations regarding gross contamination concerns;

General:

- Consideration of method reporting limits or natural background concentrations of a chemical in place of the ESL.

Soil Screening Levels

Direct Exposure:

- Use of alternative chemical toxicity factors or target risk levels;
- Elimination of direct-exposure concerns through imposition of institutional controls;
- Exclusion of direct-exposure concerns due to depth of impacted soil below ground surface (e.g., >10 meters bgs).

Indoor Air Impacts:

- Use of soil gas and/or indoor air data to more directly evaluate potential impacts;
- Use of alternative chemical toxicity factors or target risk levels.

Groundwater Protection (leaching effects):

- Consideration of alternative, target groundwater levels;

- Use of groundwater monitoring data to evaluate leaching impacts and groundwater quality concerns (most appropriate where main mass of chemical is in contact with groundwater);
- Use of laboratory leaching test to evaluate potential groundwater impacts (see Section 3.3.3).

Ecological Impact Concerns:

- Use of alternative screening levels based on site studies or published data;
- Reconsideration of need to include eco-based screening levels in highly developed or industrialized areas.

Gross Contamination:

- Use of alternative ceiling levels and/or site-specific observations and considerations for gross contamination concerns.

General:

- Consideration of method reporting limits or natural background concentrations of a chemical in place of the ESL.

In each of these examples, an alternative screening level is generated for the specified environmental concern and re-compared to site data. Models and assumptions used to generate each of the Tier 1 screening levels are discussed in detail in Appendix 1. The format of the Tier 2 Environmental Risk Assessment Report should be similar to that outlined for Tier 1 reports. Adjustments to Tier 1 screening levels should be clearly described and justified within the report and additional information included as necessary.

3.3 Tier 3 Environmental Risk Assessments

3.3.1 Purpose

Under Tier 3, alternative models and assumptions are used and fully justified to develop a detailed, comprehensive environmental risk assessment. Portions of the Tier 1 models may still be retained for some components of the risk assessment. A detailed review of the preparation of Tier 3 environmental risk assessments is beyond the scope of this document. A few potentially useful methods and some general cautions are highlighted below. Example references for the preparation of Tier 3 risk assessments are provided at the end of this section.

3.3.2 Mass-Balanced Soil Volatilization Factor Model

A good example of a useful, alternative model for evaluating soil direct-exposure concerns is the mass-balanced volatilization factor model provided in the USEPA document *Soil Screening Guidance* (USEPA 1996) and used in the City of Oakland RBCA program (Oakland 2000). This model was used in earlier versions of the USEPA Preliminary Remedial Goals (PRGs) document (pre-1995). The current PRG model, and the model reflected in the soil direct-exposure screening levels presented in this document, assumes an infinite thickness of contaminated soil at a site. For highly volatile chemicals such as vinyl chloride and even benzene, this is excessively conservative and would require the presence of tens of meters impacted soil over a large area to be justifiable. The mass-balanced model allows for the input of the actual thickness of impacted soil at a site and can result in substantially less stringent, and more realistic, screening or cleanup levels for direct-exposure concerns. Note, however, that groundwater protection concerns (i.e., soil leaching) or potential indoor-air impacts often drive screening level environmental concerns at sites impacted with highly mobile, volatile chemicals. This concern and others, as appropriate, should be evaluated in conjunction with direct-exposure concerns.

Easy-to-use spreadsheets that incorporate the mass-balanced direct-exposure model are available for downloading from the Hawaii Department of Health website (HIDOH 1995, DETIER2 spreadsheet developed by editor of this document) as well as the City of Oakland website (Oakland 2000), among other sources. Care should be taken to ensure that default toxicity factors presented in these and other spreadsheets are consistent with those used in California (see Appendix 1, Table J). In the future, a similar spreadsheet may be directly available from the RWQCB (refer to contacts listed at front of document).

3.3.3 Laboratory-Based Soil Leaching Tests

Laboratory-based soil leaching tests offer an alternative to the use of conservative, model-derived soil screening levels for groundwater protection concerns (refer to Section 3.4 in Appendix 1). These tests may be especially useful for evaluating soils impacted by inorganic chemicals (e.g., metals and salts) and relatively nonsorptive and nonvolatile organic chemicals. Screening levels for leaching of metals from soil are specifically excluded from this document. Where releases of metal compounds to soil are identified, groundwater monitoring (if appropriate) and/or laboratory-based leaching tests should be carried out to fully evaluate potential leaching impacts (refer to Section 3.4 of Appendix 1).

The USEPA Synthetic Precipitation Leaching Procedure (SPLP) is one example of laboratory-based soil leaching tests (USEPA 1994). The SPLP test differs from the more commonly referenced Toxicity Characteristic Leaching Procedure (TCLP) for hazardous

waste in that it is specifically designed to evaluate the mobility of organic and inorganic compounds in soils. The results of an SPLP test are compared to regulatory levels for disposal of materials in landfills and this is then used to determine the type of landfill most appropriate for disposal of the soil (e.g., lining, leachate collection system requirements, etc.).

The SPLP test was **not** specifically developed to evaluate leaching of chemicals from soil outside of a controlled, landfill environment but can be used to do so with some caveats. From a groundwater protection standpoint, one goal is to predict the dissolved-phase concentration of a chemical in the pore space of a saturated soil sample (i.e. the leachate) through either models or laboratory tests. The SPLP test does **not** directly provide this information. Using the SPLP test method, 100 grams of soil are added to two liters of reagent water, the sample is mixed for a specified period of time, and an extract of the regent water is analyzed for targeted chemicals. The volume of reagent water added to the sample significantly exceeds the volume of the sample pore space. This leads to significant dilution of the potential "leachate" had the volume of added reagent water only been equal to the volume of the sample pore space.

For example, the pore volume of a 100-gram sample of soil with 35% effective porosity is approximately 20 cm^3 (assumes bulk density of 1.8, total volume 57 cm^3). Adding two liters, or 2,000 cm^3, of water to the sample therefore introduces a laboratory-based, leachate "dilution factor" of approximately 100 to the SPLP test results (volume reagent divided by volume sample pore space). Concentrations of chemicals reported under the SPLP test could therefore be up to 100 times less than the dissolved-phase concentration of the chemical in a saturated sample.

The inherent dilution effect of the SPLP test method is only significant for chemicals that are highly mobile and not significantly volatile (or biodegradable). From a fate and transport perspective, the dilution factor inherent in the SPLP test could be considered to reflect the decrease in chemical concentrations due to resorption, volatilization and dilution as the leachate migrates downward and mixes with groundwater. Based on comparisons of soil leaching models that take these fate and transport considerations into account (e.g., SESOIL, see Appendix 1) and those that don't (e.g., USEPA 1996), the dilution factor inherent in the SPLP test method appears to be adequately conservative for chemicals that are at least moderately sorptive (i.e., sorption coefficient of at least 100 cm^3/g) or highly volatile (i.e., Henry's Constant of at least 0.001 atm-m3/mole.). **For moderately sorptive and/or volatile chemicals, the results of the SPLP test can be directly compared to target groundwater goals.** This includes most of the organic chemicals listed in the ESL lookup tables (refer to Table J in Appendix 1).

Chemicals listed in the ESL document that are not adequately sorptive or volatile to justify unmodified use of the SPLP test method include all inorganic compounds (e.g., metals and perchlorate) as well as acetone, 2,4 dinitrophenol and methyl ethyl ketone (very low sorption coefficients). Other organic chemicals that fail this test but only

moderately include bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, chloraniline, 1,2 dibromoethane, 2,4 dimethylphenol, 2,4 dinitrotoluene, MTBE, phenol, 1,1,1,2-tetrachloroethane and 1,1,2,2-tetrachloroethane. **For these and other relatively nonsorptive and nonvolatile chemicals not listed in the ESL tables, the results of the SPLP test should be multiplied by a factor of 100 (or a sample-specific factor) to negate the method-related dilution effect.** The sample results can then be adjusted with respect to chemical-specific and site-specific Dilution/Attenuation Factors (DAFs) that take into account volatilization, resorption, degradation and other factors anticipated to reduce the concentrations of chemicals in leachate as the leachate migrates downward and ultimately mixes with groundwater.

Relatively simple DAFs that only address mixing of leachate with groundwater can be calculated using equations provided in the USEPA *Soil Screening Guidance* (USEPA 1996), among other sources. For the Bay area, simple leachate/groundwater mixing DAFs for shallow aquifers would typically fall in the range of 5 for silty soils to 20 for sandy soils (e.g., assuming 2m thick shallow aquifer, 30% effective porosity, infiltration rate of 8.0 cm/year (3 inches/year or approximately 15% of total, average rainfall), and hydraulic conductivities of 2m/day and 15m/day, respectively). DAFs could be much higher for areas with fast moving groundwater and/or little infiltration of precipitation and lower in areas with slow moving groundwater and/or greater infiltration of precipitation. Potentially less conservative DAFs that also address resorption, volatilization and other factors can be calculated using more rigorous models such as SESOIL (see Appendix 1).

3.3.4 Tier 3 Environmental Risk Assessments for Parklands

For initial cleanup efforts at sites to be used as parks or wildlife refuges, it is strongly recommended that such areas be remediated to meet unrestricted land use (i.e., assumed residential exposure, target Excess Cancer Risk of one-in-a-million; target Hazard Index of 1.0 and address potential ecological concerns). From a strictly toxicological standpoint, a typical recreational-use exposure scenario may suggest that substantially higher concentrations of contaminants could be left in place at the site and not pose a threat to human health. Public parks are typically frequented by children, young mothers, elderly people and other groups of people with potentially elevated sensitivities to environmental contaminants, however. In addition, cleanup levels based on recreational land-use scenarios are oftentimes higher (less stringent) than levels that would be allowed for commercial/industrial properties. This intuitively goes against the concept of developing a park as "refuge" for humans and wildlife. Assumption of a limited exposure frequency and duration (e.g., 100 days per year for ten years) also puts an inherent restriction on the number of days and years that an individual can visit the park without exceeding potential health hazards. Long-term, future uses of such properties are also difficult to predict.

In some cases, remediation of proposed parklands to unrestricted land-use standards may not technically or economically feasible. This should be evaluated on a site-specific basis and receive approval from the overseeing regulatory agency. In such cases, the appropriateness of allowing unrestricted access to the area should be carefully evaluated. This could include the need to impose access restrictions on the property (i.e., based on the exposure assumptions used in the risk assessment) and/or cap impacted soils with a minimal amount of clean fill. It may also be prudent to post signs at the property entrance that warn of potential health hazards (see Section 2.9).

3.3.5 Tier 3 Reference Documents

Potentially useful reference documents for preparation of Tier 3 environmental risk assessments include the following:

Human Health Risk Assessment:

- *Superfund Exposure Assessment Manual* (USEPA 1988)
- *Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual* (Part A) (USEPA 1989a);
- *Soil Screening Guidance: Technical Background Document* (USEPA 1996);
- *CalTOX, A Multimedia Total Exposure Model For Hazardous-Waste Sites* (CalEPA 1994a);
- *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b);
- *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a);
- *Exposure Factors Handbook* (USEPA 1997a);
- St*andard Provisional Guide for Risk-Based Corrective Action* (ASTM 1995); and
- Assessing the Significance of Subsurface Contaminant Vapor Migration to Enclosed Spaces (Johnson et. al, 1998).

Ecological Risk Assessment:

- *Risk Assessment Guidance for Superfund: Volume II Environmental Evaluation Manual* (USEPA 1989b);
- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997b), and

- *Guidance for Ecological Risk Assessments at Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a,b).

The above list of references is not intended to be comprehensive. Additional risk assessment guidance should be referred to as needed.

4

References

ASTM, 1995, *Standard Provisional Guide for Risk-Based Corrective Action*: American Society for Testing and Materials, Designation E2081-00.

CalEPA, 1994a, *CalTOX, A Multimedia Total Exposure Model For Hazardous-Waste Sites*: California Department of Environmental Protection, Department of Toxics Substances Control, Version 1.5 (and updates), www.cwo.com/~herd1/caltox.htm.

CalEPA, 1994b, *Preliminary Endangerment Assessment Guidance Manual*: California Department of Environmental Protection, Department of Toxics Substances Control, January, 1994.

CalEPA, 1996a, *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities*: California Department of Environmental Protection, Department of Toxics Substances Control, August, 1996, www.dtsc.ca.gov/ScienceTechnology/index.html.

CalEPA, 1996b, *Guidance for Ecological Risk Assessments at Hazardous Waste Sites and Permitted Facilities (Parts A and B)*: California Department of Environmental Protection, Department of Toxics Substances Control, July 4, 1996, www.dtsc.ca.gov/ScienceTechnology/index.html.

DTSC, 2002, Response Actions For Sites Where Future Uses May Include Sensitive Uses: Department of Toxic Substances Control, Site Mitigation and Brownfields Reuse Program, Management Memo EO-02-002-MM (July 0, 2002).

Fetter, C. W., 1994, *Applied Hydrogeology*: Macmillan College Publishing Company, New York, ISBN 0-02-336490-4.

HIDOH, 1995, *Risk-Based Corrective Action and Decision Making at Sites With Contaminated Soil and Groundwater*: State of Hawai'i, Department of Health, December, 1995 (revised June, 1996), www.state.hi.us/doh/eh/shwb/ust/index.html

Johnson, P.C., Kemblowski, M. W., and Johnson, R.L., 1998, *Assessing the Significance of Subsurface Contaminant Vapor Migration to Enclosed Spaces*: American Petroleum Institute, Health and Environmental Sciences Department, December, 1998, API Publication No. 4674.

LBNL, 2002, *Analysis of Background Distributions of Metals in the Soil at Lawrence Berkeley National Laboratory*: University of California (Berkeley), Lawrence Berkeley Laboratory, June 2002.

MADEP, 1995, *Guidance For Disposal Site Risk Characterization*: Massachusetts Department of Environmental Protection, Bureau of Waste Site Cleanup and Office of Research and Standards, July 1995.

Oakland, 2000, *Oakland Risk-Based Corrective Action: Technical Background Document: City of Oakland, Environmental Services Division*, (prepared by L.R. Spence. Spence Environmental Engineering and M. Gomez, City of Oakland), January, 2000 (and updates), www.oaklanddpw.com/urlprogram.

NIOSH, 2003, NIOSH Pocket Guide To Chemical Hazards: National Institute for Occupational Safety and Health (NIOSH), www.cdc.gov/niosh/npg/npg.html.

RWQCBSF, 1995, *Water Quality Control Plan*: California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region, June, 1995.

RWQCBSF, 1996, *Supplemental Instructions to State Water Board December 8, 1995, Interim Guidance on Required Cleanup at Low-Risk Fuel Sites*: California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region, January 5, 1996.

RWQCBSF, 2001a, *Application of Risk-Based Screening Levels (RBSLs) And Decision Making to Sites With Impacted Soil and Groundwater* (December 2001); California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region.

RWQCBSF, 2001b, Use of City of Oakland *Urban Land Redevelopment Program Guidance Document* and Environmental Screening Levels (letter and internal memo): California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region, August 3, 2001, www.swrcb.ca.gov/~rwqcb2/ESL.htm (RWQCBSF ESL web page).

SWRCB, 2000, *Guidelines for Investigation and Cleanup of MTBE and Other Ether-Based Oxygenates* (DRAFT): State Water Resources Control Board, Division of Clean Water Programs, March 30, 2000.

UCR, 1996, *Background Concentrations of Trace and Major Elements in California Soils*: University of California (Riverside), Division of Agriculture and Natural Resources, March 1996.

USEPA, 1988, *Superfund Exposure Assessment Manual*: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Publication EPA/540/1-88/001.

USEPA, 1989a, *Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual (Part A)*: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Publication EPA/540/1-89/092.

USEPA, 1989b, *Risk Assessment Guidance for Superfund. Volume II, Environmental Evaluation Manual*: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Publication EPA/540/1-89/001.

USEPA, 1994, Synthetic Precipitation Leaching Procedure: U.S. Environmental Protection Agency, Office of Solid Waste, SW-846 Method 1312, September 1994, www.epa.gov/epaoswer/hazwaste/test/main.htm.

USEPA, 1996, *Soil Screening Guidance: Technical Background Document*: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Publication 9355.4-17A, May 1996.

USEPA, 1997a, *Exposure Factors Handbook*: U.S. Environmental Protection Agency, Office of Research and Development, Publication EPA/600/P-95/002Fa, August 1997.

USEPA, 1997b, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. U.S. Environmental Protection Agency, Environmental Response Team, Interim Final. June 5, 1997, EPA 540-R-97-006.

USEPA, 2000, *User's Guide For The Johnson and Ettinger (1991) Model For Subsurface Vapor Intrusion Into Buildings*: U.S. Environmental Protection Agency Office of Emergency and Remedial Response, September 1997 (and updates),www.epa.gov/oerrpage/superfund/programs/risk/airmodel/johnson_ettinger.htm.

USEPA, 2002, *Preliminary Remediation Goals*: U.S. Environmental Protection Agency, Region IX, October 2002, www.epa.gov/region09/waste/sfund/prg/ index.htm.

FIGURES

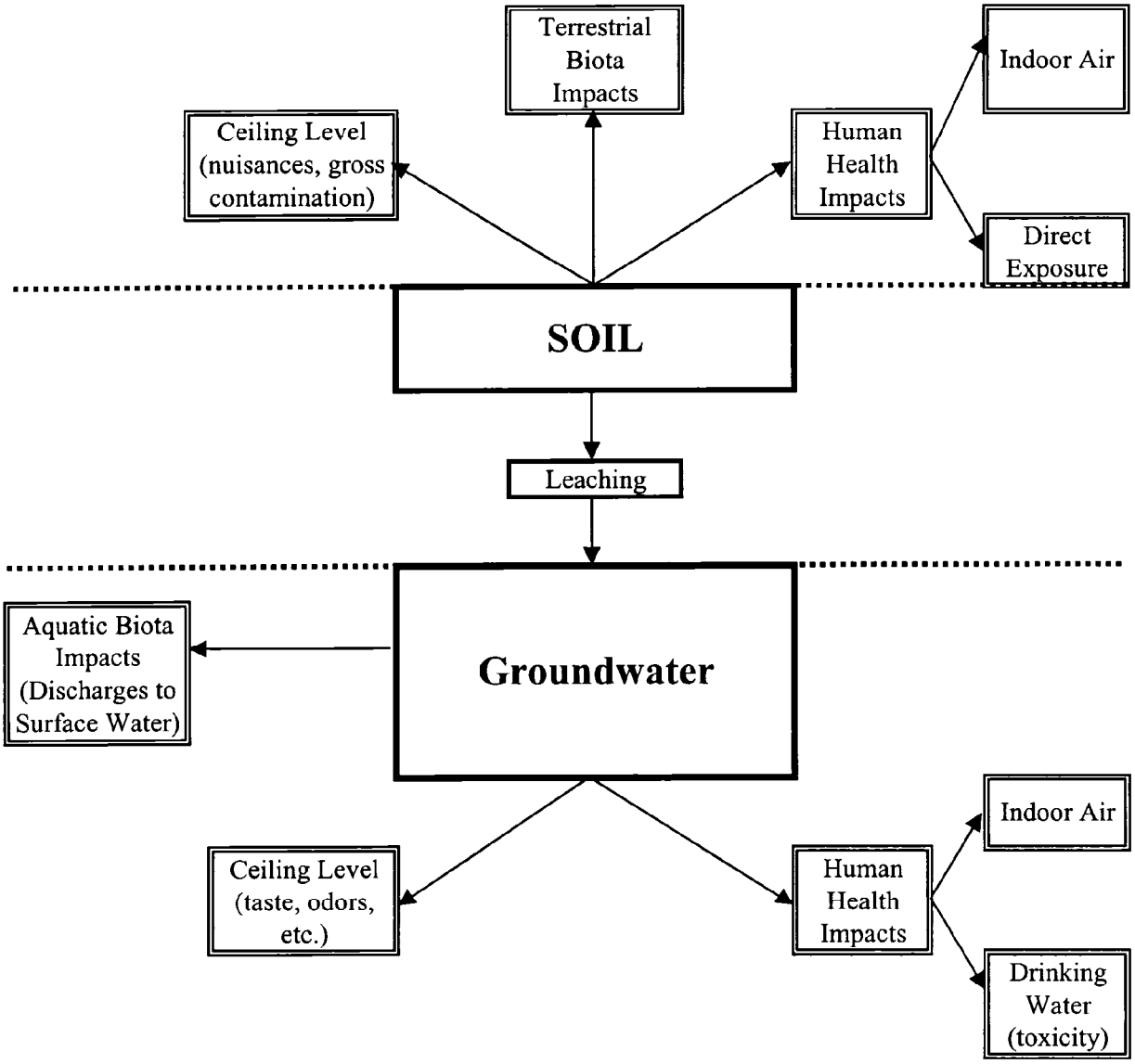

Figure 1. Summary of human health and environmental concerns considered in screening levels. Additional site-specific considerations include groundwater beneficial use, depth to impacted soil, soil type and land use. This figure is intended for Tier 1 and Tier 2 assessments only. Evaluation of environmental concerns not shown requires site-specific assessment.

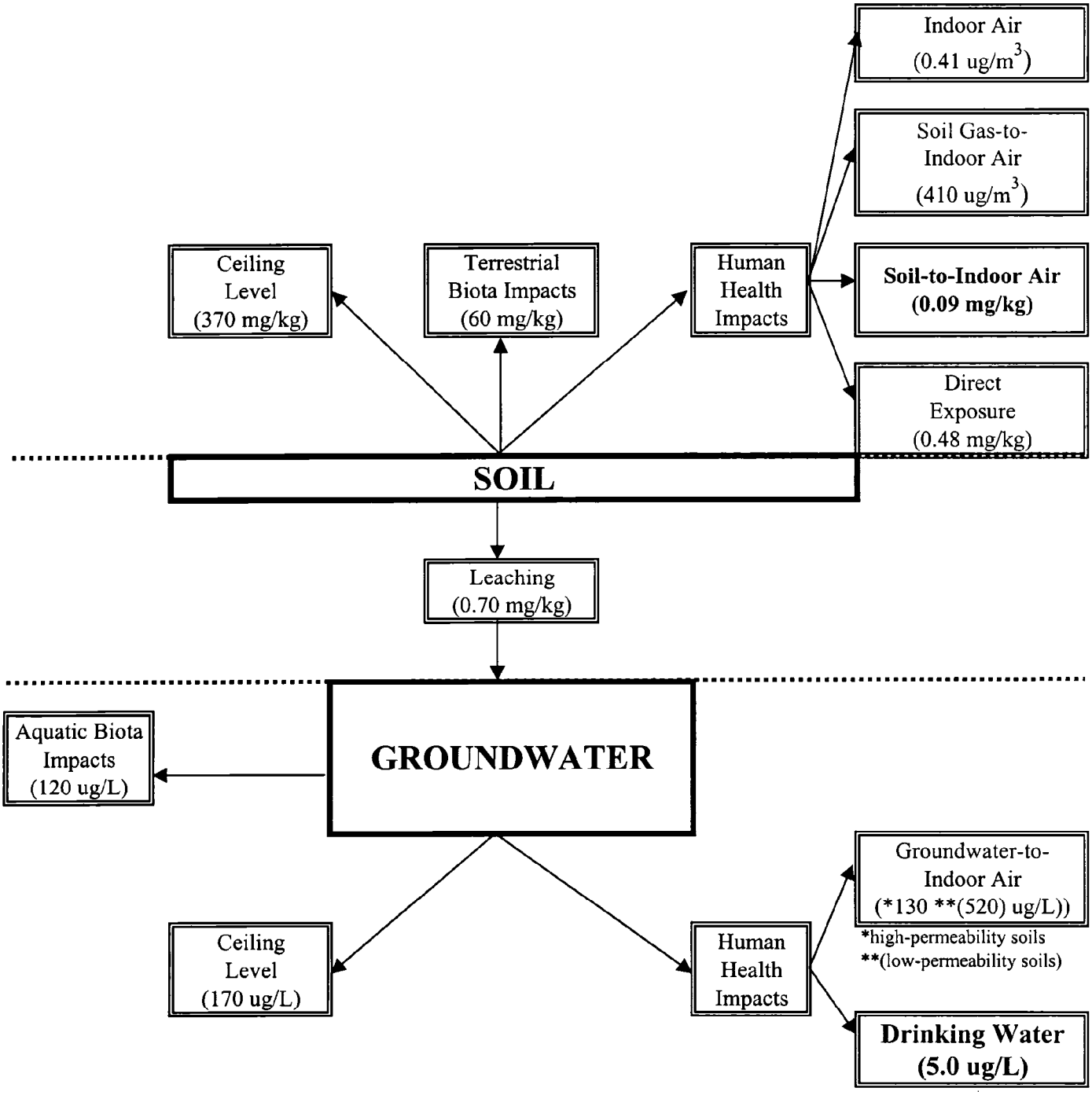

Figure 2. Summary of individual screening levels used to select final, Tier 1 soil and groundwater ESLs for tetrachloroethylene (Table A, refer also to Tables A-1 and F-1 in Appendix 1). Based on shallow soils, residential land use and potential impact to drinking water resource. Final Tier 1 ESLs for soil and groundwater are the lowest of the individual screening levels. Potential impact to indoor air drives selection final soil ESL (0.09 mg/kg). For groundwater, drinking water concerns drive selection of final ESL (5.0 ug/L). Groundwater-to-indoor air screening levels for low-permeability soils not shown in summary lookup tables (refer to Appendix 1).

STEP 1: Check with the overseeing regulatory agency to ensure that the version of the lookup tables you have is up-to-date and that the screening levels can be applied to your site (see Section 1.5).

STEP 2: Select chemicals of potential concern for site based on knowledge of past site use and/or analytical data for soil or groundwater samples collected at the site.

STEP 3: Choose appropriate lookup table based on location of impacted soil and beneficial use of impacted or potentially impacted groundwater at the subject site, as summarized below:

[1]BENEFICIAL USE OF THREATENED GROUNDWATER	[2]LOCATION OF IMPACTED SOIL	
	Shallow Soils (≤ 3m bgs)	**[3]Deep Soils (> 3m bgs)**
Current or Potential Source of Drinking Water	TABLE A	TABLE C
NOT a Current or Potential Source of Drinking Water	TABLE B	TABLE D

bgs: below ground surface

1. Shallow-most saturated zone beneath the subject site and deeper zones as appropriate.
2. Depth to top of impacted soil from ground surface (3 meters = 10 feet).
3. Application of deep soil ESLs to soils <3m deep may require institutional controls (see text).

STEP 4: Go to selected lookup table. Determine desired or anticipated future use of property - "Unrestricted Land Use Permitted" (recommended for initial use at all sites to avoid potential deed restrictions) vs "Commercial/Industrial Land Use Only".

STEP 5: Select soil ESLs for chemicals of concern from appropriate land-use column in table and/or select correlative groundwater ESLs.

STEP 6: Replace ESLs with approved laboratory method detection limit if detection limit is greater than the ESL. Replace ESLs with natural background concentration of chemical if background is higher (see text and notes at end of tables).

STEP 7: Determine vertical and lateral extent of soil and/or groundwater impacted above screening levels to extent required by overseeing agency AND/OR use selected ESLs as guide for re-use of excavated, impacted soil.

STEP 8: Evaluate additional corrective actions needed at site based on results of Step 7. (e.g., cleanup to Tier 1 ESLs, track and monitor defined groundwater plume, develop alternative screening levels in a site-specific, Tier 2 or Tier 3 environmental risk assessment, etc.). Determine specific environmental concerns for site as needed using screening levels presented in Appendix 1.

STEP 9: Submit Tier 1 Environmental Risk Assessment and work plans for additional corrective actions, as necessary, to overseeing regulatory agency.

Figure 3. Steps to selection and use of Environmental Screening Levels in Tier 1 Lookup Tables (see Section 2.2).

Figure 4. Evaluation of arsenic concentrations in soil.

[1]Concentration of Arsenic in Surface Soil	[2]Basis	Residential Land Use	Commercial/Industrial Land Use	[3]Ecological Concerns
≤5.5 mg/kg	[4]Typical average concentration of As in Bay Area soils.	No action required.	No action required.	No action required.
>5.5 mg/kg	Potentially above background for Bay Area soils. Background could range up to 20+ mg/kg in some areas.	Further evaluation of site background concentrations required (sample data, data from nearby areas, etc.). Residential land use probably not permitted without remediation to background levels. Evaluate potential impacts to groundwater as necessary.	Further evaluation of site background concentrations required (sample data, data from nearby areas, etc.). Risk management measures needed may be needed to address potential dust impacts to nearby residential areas. Evaluate potential impacts to groundwater as necessary.	Further evaluation of potential site background concentrations required (sample data, data for nearby areas, etc.). Ecological risk assessment may be needed for areas where sensitive habitats are threatened, including potential discharge of impacted groundwater to a surface water habitat.
≥16 mg/kg	Commercial/ Industrial direct-contact screening level adjusted to target risk of 10^{-5} (see Table K-2)	Same as above.	Soil remediation and/or risk management measures needed. May include need to provide subsurface utility corridors for future redevelopment. Evaluate potential impacts to groundwater as necessary.	Same as above.
≥40 mg/kg	Ecological screening level for Commercial/ Industrial sites (see Table A-2)	Same as above.	Same as above.	Ecological risk assessment needed for sites where sensitive habitats are threatened.

For general reference only. More stringent criteria may be applied on a site-specific basis.

1. Shallow soils defined as soils within 3m (10ft) of ground surface.
2. Refer to noted text or table in document.
3. An ecological risk assessment may be required at lower soil concentrations than indicated for sites within or adjacent to sensitive habitats (e.g., adjacent to sensitive wetlands, endangered species threatened, etc.).
4. Arithmetic mean arsenic concentration calculated for all soils at Lawrence Berkeley Laboratory facility (LBNL 2002). Highest reported concentration of arsenic in soils at LBNL facility is 42 mg/kg.

TABLES

TABLE A: SHALLOW SOIL (≤3M BGS) - WATER IS A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.9).

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil		[3]Groundwater (ug/L)
	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
ACENAPHTHENE	1.6E+01	1.6E+01	2.0E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	2.4E-01	2.4E-01	7.0E+02
ALDRIN	2.9E-02	1.0E-01	2.0E-03
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	6.3E+00	4.0E+01	6.0E+00
ARSENIC	5.5E+00	5.5E+00	3.6E+01
BARIUM	7.5E+02	1.5E+03	1.0E+03
BENZENE	4.4E-02	4.4E-02	1.0E+00
BENZO(a)ANTHRACENE	3.8E-01	1.3E+00	2.7E-02
BENZO(b)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(k)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	3.8E-02	1.3E-01	1.4E-02
BERYLLIUM	4.0E+00	8.0E+00	2.7E+00
BIPHENYL, 1,1-	6.5E-01	6.5E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.8E-04	1.8E-04	1.4E-02
BIS(2-CHLOROISOPROPYL)ETHER	5.4E-03	5.4E-03	5.0E-01
BIS(2-ETHYLHEXYL)PHTHALATE	6.6E+01	6.6E+01	4.0E+00
BORON	1.6E+00	2.0E+00	1.6E+00
BROMODICHLOROMETHANE	1.2E-02	3.9E-02	1.0E+02
BROMOFORM	2.2E+00	2.2E+00	1.0E+02
BROMOMETHANE	2.2E-01	3.9E-01	9.8E+00
CADMIUM	1.7E+00	7.4E+00	2.2E+00
CARBON TETRACHLORIDE	1.2E-02	3.5E-02	5.0E-01
CHLORDANE	4.4E-01	1.7E+00	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	9.8E-02	2.7E-01	1.0E+02
CHLOROMETHANE	2.9E-01	4.2E-01	2.7E+00
CHLOROPHENOL, 2-	1.2E-02	1.2E-02	1.8E-01
CHROMIUM (Total)	5.8E+01	5.8E+01	5.0E+01
CHROMIUM III	7.5E+02	7.5E+02	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	3.8E+00	1.3E+01	2.9E-01
COBALT	4.0E+01	8.0E+01	3.0E+00
COPPER	2.3E+02	2.3E+02	3.1E+00
CYANIDE (Free)	1.0E+02	5.0E+02	1.0E+00
DIBENZO(a,h)ANTHTRACENE	1.1E-01	3.8E-01	8.5E-03
DIBROMOCHLOROMETHANE	1.9E-02	5.8E-02	1.0E+02
1,2-DIBROMO-3-CHLOROPROPANE	1.1E-03	1.1E-03	2.0E-01
DIBROMOETHANE, 1,2-	3.3E-04	3.3E-04	5.0E-02
DICHLOROBENZENE, 1,2-	1.1E+00	1.1E+00	1.0E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
DICHLOROBENZENE, 1,3-	7.2E-01	7.2E-01	6.3E+00
DICHLOROBENZENE, 1,4-	4.7E-02	1.3E-01	5.0E+00
DICHLOROBENZIDINE, 3,3-	7.7E-03	7.7E-03	2.9E-02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.4E+00	1.0E+01	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.7E+00	4.0E+00	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.7E+00	4.0E+00	1.0E-03
DICHLOROETHANE, 1,1-	2.0E-01	2.0E-01	5.0E+00
DICHLOROETHANE, 1,2-	4.5E-03	4.5E-03	5.0E-01
DICHLOROETHYLENE, 1,1-	1.0E+00	1.0E+00	6.0E+00
DICHLOROETHYLENE, Cis 1,2-	1.9E-01	1.9E-01	6.0E+00
DICHLOROETHYLENE, Trans 1,2-	6.7E-01	6.7E-01	1.0E+01
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	5.2E-02	1.2E-01	5.0E+00
DICHLOROPROPENE, 1,3-	3.3E-02	5.9E-02	5.0E-01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	6.7E-01	6.7E-01	1.0E+02
DINITROPHENOL, 2,4-	4.0E-02	4.0E-02	1.4E+01
DINITROTOLUENE, 2,4-	8.5E-04	8.5E-04	1.1E-01
1,4 DIOXANE	1.8E-03	1.8E-03	3.0E+00
DIOXIN (2,3,7,8-TCDD)	4.5E-06	1.8E-05	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHYLBENZENE	3.3E+00	3.3E+00	3.0E+01
FLUORANTHENE	4.0E+01	4.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	2.7E-01	9.6E-01	1.0E+00
HEXACHLOROBUTADIENE	1.0E+00	1.0E+00	2.1E-01
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	2.4E+00	2.4E+00	7.0E-01
INDENO(1,2,3-cd)PYRENE	3.8E-01	1.3E+00	2.9E-02
LEAD	2.0E+02	7.5E+02	2.5E+00
MERCURY	2.5E+00	1.0E+01	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	7.7E-02	7.7E-02	5.0E+00
METHYL ETHYL KETONE	3.9E+00	3.9E+00	4.2E+03
METHYL ISOBUTYL KETONE	2.8E+00	2.8E+00	1.2E+02
METHYL MERCURY	1.2E+00	1.0E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.3E-02	2.3E-02	5.0E+00
MOLYBDENUM	4.0E+01	4.0E+01	3.5E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil		[3]Groundwater (ug/L)
	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
NAPHTHALENE	4.2E+00	4.2E+00	2.1E+01
NICKEL	1.5E+02	1.5E+02	8.2E+00
PENTACHLOROPHENOL	4.4E+00	5.0E+00	1.0E+00
PERCHLORATE	7.0E-03	7.0E-03	7.0E-01
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	7.6E-02	7.6E-02	5.0E+00
POLYCHLORINATED BIPHENYLS (PCBs)	2.2E-01	7.4E-01	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	1.0E+01	1.0E+01	5.0E+00
SILVER	2.0E+01	4.0E+01	1.9E-01
STYRENE	1.5E+00	1.5E+00	1.0E+01
tert-BUTYL ALCOHOL	7.3E-02	7.3E-02	1.2E+01
TETRACHLOROETHANE, 1,1,1,2-	2.4E-02	2.4E-02	1.3E+00
TETRACHLOROETHANE, 1,1,2,2-	9.0E-03	1.8E-02	1.0E+00
TETRACHLOROETHYLENE	8.8E-02	2.5E-01	5.0E+00
THALLIUM	1.0E+00	1.3E+01	2.0E+00
TOLUENE	2.9E+00	2.9E+00	4.0E+01
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	1.0E+02	1.0E+02
TPH (middle distillates)	1.0E+02	1.0E+02	1.0E+02
TPH (residual fuels)	5.0E+02	1.0E+03	1.0E+02
TRICHLOROBENZENE, 1,2,4-	7.6E+00	7.6E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.3E-02	7.0E-02	5.0E+00
TRICHLOROETHYLENE	2.6E-01	4.6E-01	5.0E+00
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.7E-01	1.7E-01	5.0E-01
VANADIUM	1.1E+02	2.0E+02	1.5E+01
VINYL CHLORIDE	6.7E-03	1.9E-02	5.0E-01
XYLENES	1.5E+00	1.5E+00	1.3E+01
ZINC	6.0E+02	6.0E+02	8.1E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil		[3]Groundwater (ug/L)
	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	2.0	4.0	not applicable
Sodium Adsorption Ratio	5.0	12	not applicable

Notes:

1. Shallow soils defined as soils less than or equal to 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into a freshwater, marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables A-1 and A-2.

Source of groundwater ESLs: Refer to Appendix 1, Table F-1a.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).

Soil ESLs intended to address direct-exposure, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**

Groundwater ESLs intended to be address drinking water, surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**

Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).

Refer to appendices for summary of ESL components.

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE B: SHALLOW SOIL (≤3M BGS) - WATER IS NOT A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.9).
- Assumption that groundwater is not a current or potential source of drinking water should be approved by overseeing regulatory agency prior to use of this table (see Section 2.3).

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
ACENAPHTHENE	1.9E+01	1.9E+01	2.3E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	2.9E-02	1.0E-01	1.3E-01
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	6.3E+00	4.0E+01	3.0E+01
ARSENIC	5.5E+00	5.5E+00	3.6E+01
BARIUM	7.5E+02	1.5E+03	1.0E+03
BENZENE	1.8E-01	3.8E-01	4.6E+01
BENZO(a)ANTHRACENE	3.8E-01	1.3E+00	2.7E-02
BENZO(b)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(k)FLUORANTHENE	3.8E-01	1.3E+00	4.0E-01
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	3.8E-02	1.3E-01	1.4E-02
BERYLLIUM	4.0E+00	8.0E+00	2.7E+00
BIPHENYL, 1,1-	6.5E+00	6.5E+00	5.0E+00
BIS(2-CHLOROETHYL)ETHER	4.0E-03	1.3E-02	6.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	6.6E-01	6.6E-01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	1.6E+02	5.3E+02	3.2E+01
BORON	1.6E+00	2.0E+00	1.6E+00
BROMODICHLOROMETHANE	1.2E-02	3.9E-02	1.6E+02
BROMOFORM	6.1E+01	6.9E+01	3.2E+03
BROMOMETHANE	2.2E-01	5.1E-01	1.6E+02
CADMIUM	1.7E+00	7.4E+00	2.2E+00
CARBON TETRACHLORIDE	1.2E-02	3.5E-02	9.5E+00
CHLORDANE	4.4E-01	1.7E+00	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	9.8E-02	2.7E-01	3.4E+02
CHLOROMETHANE	2.9E-01	8.1E-01	1.7E+02
CHLOROPHENOL, 2-	1.2E-01	1.2E-01	1.8E+00
CHROMIUM (Total)	5.8E+01	5.8E+01	1.8E+02
CHROMIUM III	7.5E+02	7.5E+02	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	3.8E+00	1.3E+01	3.5E-01
COBALT	4.0E+01	8.0E+01	3.0E+00
COPPER	2.3E+02	2.3E+02	3.1E+00
CYANIDE (Free)	1.0E+02	5.0E+02	1.0E+00
DIBENZO(a,h)ANTHTRACENE	1.1E-01	3.8E-01	2.5E-01
DIBROMOCHLOROMETHANE	1.9E-02	5.8E-02	1.8E+02

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
1,2-DIBROMO-3-CHLOROPROPANE	1.1E-03	1.1E-03	2.0E-01
DIBROMOETHANE, 1,2-	7.3E-03	2.1E-02	1.6E+02
DICHLOROBENZENE, 1,2-	1.6E+00	1.6E+00	1.4E+01
DICHLOROBENZENE, 1,3-	3.2E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	4.7E-02	1.3E-01	1.5E+01
DICHLOROBENZIDINE, 3,3-	4.0E-01	1.4E+00	2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.4E+00	1.0E+01	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.7E+00	4.0E+00	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.7E+00	4.0E+00	1.0E-03
DICHLOROETHANE, 1,1-	3.3E-01	9.1E-01	4.7E+01
DICHLOROETHANE, 1,2-	2.5E-02	6.9E-02	2.0E+02
DICHLOROETHYLENE, 1,1-	4.3E+00	4.3E+00	2.5E+01
DICHLOROETHYLENE, Cis 1,2-	1.6E+00	3.6E+00	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	3.1E+00	7.3E+00	5.9E+02
DICHLOROPHENOL, 2,4-	3.0E+00	3.0E+00	3.0E+00
DICHLOROPROPANE, 1,2-	5.2E-02	1.5E-01	1.0E+02
DICHLOROPROPENE, 1,3-	3.3E-02	9.1E-02	4.9E+01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	7.4E-01	7.4E-01	1.1E+02
DINITROPHENOL, 2,4-	2.1E-01	2.1E-01	7.5E+01
DINITROTOLUENE, 2,4-	8.6E-01	8.6E-01	1.2E+02
1,4 DIOXANE	1.8E+01	3.0E+01	5.0E+04
DIOXIN (2,3,7,8-TCDD)	4.5E-06	1.8E-05	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHYLBENZENE	4.7E+00	1.3E+01	2.9E+02
FLUORANTHENE	4.0E+01	4.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	2.7E-01	9.6E-01	3.7E+00
HEXACHLOROBUTADIENE	3.7E+00	2.2E+01	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	1.2E+01	4.1E+01	1.2E+01
INDENO(1,2,3-cd)PYRENE	3.8E-01	1.3E+00	2.9E-02
LEAD	2.0E+02	7.5E+02	2.5E+00
MERCURY	2.5E+00	1.0E+01	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	5.2E-01	1.5E+00	2.2E+03

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
METHYL ETHYL KETONE	1.3E+01	1.3E+01	1.4E+04
METHYL ISOBUTYL KETONE	3.9E+00	3.9E+00	1.7E+02
METHYL MERCURY	1.2E+00	1.0E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.0E+00	5.6E+00	1.8E+03
MOLYBDENUM	4.0E+01	4.0E+01	2.4E+02
NAPHTHALENE	4.5E+00	4.8E+00	2.4E+01
NICKEL	1.5E+02	1.5E+02	8.2E+00
PENTACHLOROPHENOL	4.4E+00	5.0E+00	7.9E+00
PERCHLORATE	1.2E+00	1.2E+00	6.0E+02
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	1.9E+01	1.9E+01	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	2.2E-01	7.4E-01	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	1.0E+01	1.0E+01	5.0E+00
SILVER	2.0E+01	4.0E+01	1.9E-01
STYRENE	1.5E+01	1.5E+01	1.0E+02
tert-BUTYL ALCOHOL	1.0E+02	1.1E+02	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	3.1E+00	7.2E+00	9.3E+02
TETRACHLOROETHANE, 1,1,2,2-	9.0E-03	2.5E-02	1.9E+02
TETRACHLOROETHYLENE	8.8E-02	2.5E-01	1.2E+02
THALLIUM	1.0E+00	1.3E+01	2.0E+01
TOLUENE	9.3E+00	9.3E+00	1.3E+02
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	4.0E+02	5.0E+02
TPH (middle distillates)	5.0E+02	5.0E+02	6.4E+02
TPH (residual fuels)	5.0E+02	1.0E+03	6.4E+02
TRICHLOROBENZENE, 1,2,4-	7.6E+00	7.6E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.3E-02	9.1E-02	3.5E+02
TRICHLOROETHYLENE	2.6E-01	7.3E-01	3.6E+02
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	6.9E+00	1.0E+01	4.9E+02
VANADIUM	1.1E+02	2.0E+02	1.9E+01

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
VINYL CHLORIDE	6.7E-03	1.9E-02	4.0E+00
XYLENES	1.5E+00	1.5E+00	1.3E+01
ZINC	6.0E+02	6.0E+02	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	2.0	4.0	not applicable
Sodium Adsorption Ratio	5.0	12	not applicable

Notes:

1. Shallow soils defined as soils less than or equal to 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables A-1 and A-2.

Source of groundwater ESLs: Refer to Appendix 1, Table F-1b.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).

Soil ESLs intended to address direct-exposure, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**

Groundwater ESLs intended to address surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**

Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).

Refer to appendices for summary of ESL components.

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE C: DEEP SOIL (>3M BGS) - WATER IS A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.9).
- ESLs for deep soils may be applicable to soils <3m below ground surface at commercial/industrial sites provided institutional controls are put in place to maintain an adequate cap and provide proper management of soil if exposed in future (see Section 2.4 and Section 2.9).

TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS a Current or Potential Source of Drinking Water

	[1]Deep Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
ACENAPHTHENE	1.6E+01	1.6E+01	2.0E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	2.4E-01	2.4E-01	7.0E+02
ALDRIN	1.2E+00	1.2E+00	2.0E-03
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	3.1E+02	3.1E+02	6.0E+00
ARSENIC	1.6E+01	1.6E+01	3.6E+01
BARIUM	2.5E+03	2.5E+03	1.0E+03
BENZENE	4.4E-02	4.4E-02	1.0E+00
BENZO(a)ANTHRACENE	1.2E+01	1.2E+01	2.7E-02
BENZO(b)FLUORANTHENE	1.5E+01	1.5E+01	2.9E-02
BENZO(k)FLUORANTHENE	2.7E+00	2.7E+00	2.9E-02
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	1.5E+00	1.5E+00	1.4E-02
BERYLLIUM	9.8E+01	9.8E+01	2.7E+00
BIPHENYL, 1,1-	6.5E-01	6.5E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.8E-04	1.8E-04	1.4E-02
BIS(2-CHLOROISOPROPYL)ETHER	5.4E-03	5.4E-03	5.0E-01
BIS(2-ETHYLHEXYL)PHTHALATE	6.6E+01	6.6E+01	4.0E+00
BORON	4.6E+04	4.6E+04	1.6E+00
BROMODICHLOROMETHANE	1.2E-02	3.9E-02	1.0E+02
BROMOFORM	2.2E+00	2.2E+00	1.0E+02
BROMOMETHANE	2.2E-01	3.9E-01	9.8E+00
CADMIUM	3.8E+01	3.8E+01	2.2E+00
CARBON TETRACHLORIDE	1.2E-02	3.5E-02	5.0E-01
CHLORDANE	1.5E+01	1.5E+01	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	9.8E-02	2.7E-01	1.0E+02
CHLOROMETHANE	2.9E-01	4.2E-01	2.7E+00
CHLOROPHENOL, 2-	1.2E-02	1.2E-02	1.8E-01
CHROMIUM (Total)	5.8E+01	5.8E+01	5.0E+01
CHROMIUM III	2.5E+03	5.0E+03	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	1.9E+01	1.9E+01	2.9E-01
COBALT	9.4E+01	9.4E+01	3.0E+00
COPPER	2.5E+03	5.0E+03	3.1E+00
CYANIDE (Free)	5.0E+02	1.0E+03	1.0E+00
DIBENZO(a,h)ANTHTRACENE	4.3E+00	4.3E+00	8.5E-03
DIBROMOCHLOROMETHANE	1.9E-02	5.8E-02	1.0E+02
1,2-DIBROMO-3-CHLOROPROPANE	1.1E-03	1.1E-03	2.0E-01

TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Deep Soil		[3]Groundwater (ug/L)
	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
DIBROMOETHANE, 1,2-	3.3E-04	3.3E-04	5.0E-02
DICHLOROBENZENE, 1,2-	1.1E+00	1.1E+00	1.0E+01
DICHLOROBENZENE, 1,3-	7.2E-01	7.2E-01	6.3E+00
DICHLOROBENZENE, 1,4-	4.7E-02	1.3E-01	5.0E+00
DICHLOROBENZIDINE, 3,3-	7.7E-03	7.7E-03	2.9E-02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	1.2E+02	1.2E+02	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	8.7E+01	8.7E+01	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	4.3E+00	4.3E+00	1.0E-03
DICHLOROETHANE, 1,1-	2.0E-01	2.0E-01	5.0E+00
DICHLOROETHANE, 1,2-	4.5E-03	4.5E-03	5.0E-01
DICHLOROETHYLENE, 1,1-	1.0E+00	1.0E+00	6.0E+00
DICHLOROETHYLENE, Cis 1,2-	1.9E-01	1.9E-01	6.0E+00
DICHLOROETHYLENE, Trans 1,2-	6.7E-01	6.7E-01	1.0E+01
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	5.2E-02	1.2E-01	5.0E+00
DICHLOROPROPENE, 1,3-	3.3E-02	5.9E-02	5.0E-01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	6.7E-01	6.7E-01	1.0E+02
DINITROPHENOL, 2,4-	4.0E-02	4.0E-02	1.4E+01
DINITROTOLUENE, 2,4-	8.5E-04	8.5E-04	1.1E-01
1,4 DIOXANE	1.8E-03	1.8E-03	3.0E+00
DIOXIN (2,3,7,8-TCDD)	2.3E-04	2.3E-04	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHYLBENZENE	3.3E+00	3.3E+00	3.0E+01
FLUORANTHENE	6.0E+01	6.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	1.1E+01	1.1E+01	1.0E+00
HEXACHLOROBUTADIENE	1.0E+00	1.0E+00	2.1E-01
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	2.4E+00	2.4E+00	7.0E-01
INDENO(1,2,3-cd)PYRENE	7.7E+00	7.7E+00	2.9E-02
LEAD	7.5E+02	7.5E+02	2.5E+00
MERCURY	1.1E+02	1.1E+02	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	7.7E-02	7.7E-02	5.0E+00
METHYL ETHYL KETONE	3.9E+00	3.9E+00	4.2E+03
METHYL ISOBUTYL KETONE	2.8E+00	2.8E+00	1.2E+02

TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS a Current or Potential Source of Drinking Water

	[1]Deep Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
METHYL MERCURY	4.1E+01	4.1E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.3E-02	2.3E-02	5.0E+00
MOLYBDENUM	2.5E+03	3.9E+03	3.5E+01
NAPHTHALENE	4.2E+00	4.2E+00	2.1E+01
NICKEL	1.0E+03	1.0E+03	8.2E+00
PENTACHLOROPHENOL	5.3E+00	5.3E+00	1.0E+00
PERCHLORATE	7.0E-03	7.0E-03	7.0E-01
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	7.6E-02	7.6E-02	5.0E+00
POLYCHLORINATED BIPHENYLS (PCBs)	6.3E+00	6.3E+00	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	2.5E+03	3.9E+03	5.0E+00
SILVER	2.5E+03	3.9E+03	1.9E-01
STYRENE	1.5E+00	1.5E+00	1.0E+01
tert-BUTYL ALCOHOL	7.3E-02	7.3E-02	1.2E+01
TETRACHLOROETHANE, 1,1,1,2-	2.4E-02	2.4E-02	1.3E+00
TETRACHLOROETHANE, 1,1,2,2-	9.0E-03	1.8E-02	1.0E+00
TETRACHLOROETHYLENE	8.8E-02	2.5E-01	5.0E+00
THALLIUM	5.1E+01	5.1E+01	2.0E+00
TOLUENE	2.9E+00	2.9E+00	4.0E+01
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	1.0E+02	1.0E+02
TPH (middle distillates)	1.0E+02	1.0E+02	1.0E+02
TPH (residual fuels)	1.0E+03	1.0E+03	1.0E+02
TRICHLOROBENZENE, 1,2,4-	7.6E+00	7.6E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.3E-02	7.0E-02	5.0E+00
TRICHLOROETHYLENE	2.6E-01	4.6E-01	5.0E+00
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.7E-01	1.7E-01	5.0E-01
VANADIUM	2.5E+03	5.0E+03	1.5E+01

TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS a Current or Potential Source of Drinking Water

	[1]Deep Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
VINYL CHLORIDE	6.7E-03	1.9E-02	5.0E-01
XYLENES	1.5E+00	1.5E+00	1.3E+01
ZINC	2.5E+03	5.0E+03	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable

Notes:

1. Deep soils defined as soils greater than 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into a freshwater, marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables C-1 and C-2.

Source of groundwater ESLs: Refer to Appendix 1, Table F-1a.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).

Soil ESLs intended to address human health, groundwater protection and nuisance concerns under a construction/trench worker exposure scenario and noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**

Groundwater ESLs intended to be address drinking water, surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**

Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).

Refer to appendices for summary of ESL components.

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE D: DEEP SOIL (>3M BGS) - WATER IS NOT A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.9).
- -- Assumption that groundwater is not a current or potential source of drinking water should be approved by overseeing regulatory agency prior to use of this table (see Section 2.3).
- ESLs for deep soils may be applicable to soils <3m below ground surface at commercial/industrial sites provided institutional controls are put in place to maintain an adequate cap and provide proper management of soil if exposed in future (see Section 2.4 and Section 2.9).

TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Deep Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
ACENAPHTHENE	1.9E+01	1.9E+01	2.3E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	1.2E+00	1.2E+00	1.3E-01
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	3.1E+02	3.1E+02	3.0E+01
ARSENIC	1.6E+01	1.6E+01	3.6E+01
BARIUM	2.5E+03	2.5E+03	1.0E+03
BENZENE	1.8E-01	5.0E-01	4.6E+01
BENZO(a)ANTHRACENE	1.2E+01	1.2E+01	2.7E-02
BENZO(b)FLUORANTHENE	1.5E+01	1.5E+01	2.9E-02
BENZO(k)FLUORANTHENE	1.5E+01	1.5E+01	4.0E-01
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	1.5E+00	1.5E+00	1.4E-02
BERYLLIUM	9.8E+01	9.8E+01	2.7E+00
BIPHENYL, 1,1-	6.5E+00	6.5E+00	5.0E+00
BIS(2-CHLOROETHYL)ETHER	4.0E-03	1.3E-02	6.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	6.6E-01	6.6E-01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	5.3E+02	5.3E+02	3.2E+01
BORON	4.6E+04	4.6E+04	1.6E+00
BROMODICHLOROMETHANE	1.2E-02	3.9E-02	1.6E+02
BROMOFORM	6.9E+01	6.9E+01	3.2E+03
BROMOMETHANE	2.2E-01	5.1E-01	1.6E+02
CADMIUM	3.8E+01	3.8E+01	2.2E+00
CARBON TETRACHLORIDE	1.2E-02	3.5E-02	9.5E+00
CHLORDANE	1.5E+01	1.5E+01	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	9.8E-02	2.7E-01	3.4E+02
CHLOROMETHANE	2.9E-01	8.1E-01	1.7E+02
CHLOROPHENOL, 2-	1.2E-01	1.2E-01	1.8E+00
CHROMIUM (Total)	5.8E+01	5.8E+01	1.8E+02
CHROMIUM III	2.5E+03	5.0E+03	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	2.3E+01	2.3E+01	3.5E-01
COBALT	9.4E+01	9.4E+01	3.0E+00
COPPER	2.5E+03	5.0E+03	3.1E+00
CYANIDE (Free)	5.0E+02	1.0E+03	1.0E+00
DIBENZO(a,h)ANTHTRACENE	4.3E+00	4.3E+00	2.5E-01
DIBROMOCHLOROMETHANE	1.9E-02	5.8E-02	1.8E+02
1,2-DIBROMO-3-CHLOROPROPANE	1.1E-03	1.1E-03	2.0E-01

TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Deep Soil		[3]Groundwater (ug/L)
	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	
DIBROMOETHANE, 1,2-	7.3E-03	2.1E-02	1.6E+02
DICHLOROBENZENE, 1,2-	1.6E+00	1.6E+00	1.4E+01
DICHLOROBENZENE, 1,3-	7.4E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	4.7E-02	1.3E-01	1.5E+01
DICHLOROBENZIDINE, 3,3-	1.7E+01	1.7E+01	2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	1.2E+02	1.2E+02	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	8.7E+01	8.7E+01	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	4.3E+00	4.3E+00	1.0E-03
DICHLOROETHANE, 1,1-	3.3E-01	9.1E-01	4.7E+01
DICHLOROETHANE, 1,2-	2.5E-02	6.9E-02	2.0E+02
DICHLOROETHYLENE, 1,1-	4.3E+00	4.3E+00	2.5E+01
DICHLOROETHYLENE, Cis 1,2-	1.6E+00	3.6E+00	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	3.1E+00	7.3E+00	5.9E+02
DICHLOROPHENOL, 2,4-	3.0E+00	3.0E+00	3.0E+00
DICHLOROPROPANE, 1,2-	5.2E-02	1.5E-01	1.0E+02
DICHLOROPROPENE, 1,3-	3.3E-02	9.1E-02	4.9E+01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	7.4E-01	7.4E-01	1.1E+02
DINITROPHENOL, 2,4-	2.1E-01	2.1E-01	7.5E+01
DINITROTOLUENE, 2,4-	8.6E-01	8.6E-01	1.2E+02
1,4 DIOXANE	3.0E+01	3.0E+01	5.0E+04
DIOXIN (2,3,7,8-TCDD)	2.3E-04	2.3E-04	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHYLBENZENE	4.7E+00	1.3E+01	2.9E+02
FLUORANTHENE	6.0E+01	6.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	1.1E+01	1.1E+01	3.7E+00
HEXACHLOROBUTADIENE	2.3E+01	2.3E+01	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	4.1E+01	4.1E+01	1.2E+01
INDENO(1,2,3-cd)PYRENE	7.7E+00	7.7E+00	2.9E-02
LEAD	7.5E+02	7.5E+02	2.5E+00
MERCURY	1.1E+02	1.1E+02	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	5.2E-01	1.5E+00	2.2E+03
METHYL ETHYL KETONE	1.3E+01	1.3E+01	1.4E+04
METHYL ISOBUTYL KETONE	3.9E+00	3.9E+00	1.7E+02

TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Deep Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
METHYL MERCURY	4.1E+01	4.1E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.0E+00	5.6E+00	1.8E+03
MOLYBDENUM	2.5E+03	3.9E+03	2.4E+02
NAPHTHALENE	4.5E+00	4.8E+00	2.4E+01
NICKEL	1.0E+03	1.0E+03	8.2E+00
PENTACHLOROPHENOL	4.2E+01	4.2E+01	7.9E+00
PERCHLORATE	1.2E+00	1.2E+00	6.0E+02
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	1.9E+01	1.9E+01	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	6.3E+00	6.3E+00	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	2.5E+03	3.9E+03	5.0E+00
SILVER	2.5E+03	3.9E+03	1.9E-01
STYRENE	1.5E+01	1.5E+01	1.0E+02
tert-BUTYL ALCOHOL	1.1E+02	1.1E+02	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	1.6E+01	1.6E+01	9.3E+02
TETRACHLOROETHANE, 1,1,2,2-	9.0E-03	2.5E-02	1.9E+02
TETRACHLOROETHYLENE	8.8E-02	2.5E-01	1.2E+02
THALLIUM	5.1E+01	5.1E+01	2.0E+01
TOLUENE	9.3E+00	9.3E+00	1.3E+02
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	4.0E+02	4.0E+02	5.0E+02
TPH (middle distillates)	5.0E+02	5.0E+02	6.4E+02
TPH (residual fuels)	1.0E+03	1.0E+03	6.4E+02
TRICHLOROBENZENE, 1,2,4-	7.6E+00	7.6E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.3E-02	9.1E-02	3.5E+02
TRICHLOROETHYLENE	2.6E-01	7.3E-01	3.6E+02
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.6E+02	1.6E+02	4.9E+02
VANADIUM	2.5E+03	5.0E+03	1.9E+01

TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Deep Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
VINYL CHLORIDE	6.7E-03	1.9E-02	4.0E+00
XYLENES	1.5E+00	1.5E+00	1.3E+01
ZINC	2.5E+03	5.0E+03	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable

Notes:

1. Deep soils defined as soils greater than 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables D-1 and D-2.
Source of groundwater ESLs: Refer to Appendix 1, Table F-1b.
Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).
Soil ESLs intended to address human health, groundwater protection and nuisance concerns under a construction/trench worker exposure scenario and noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**
Groundwater ESLs intended to address surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**
Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).
Refer to appendices for summary of ESL components.
TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE E: SHALLOW SOIL GAS AND INDOOR AIR

Notes:

- Shallow soil gas intended to reflect soil gas zero to five feet below ground surface or the foundation of a building. Collection of soil gas data from depths <3 feet below ground surface in open areas is generally not practical (see Section 2.6).

TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Indoor Air and Soil Gas

	INDOOR AIR SCREENING LEVELS		[2]SHALLOW SOIL GAS SCREENING LEVELS	
CHEMICAL PARAMETER	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)
ACENAPHTHENE	4.4E+01	6.1E+01	4.4E+04	1.2E+05
ACENAPHTHYLENE	2.9E+01	4.1E+01	2.9E+04	8.2E+04
ACETONE	7.3E+01	1.0E+02	7.3E+04	2.0E+05
ALDRIN				
ANTHRACENE	2.3E+02	3.2E+02	2.3E+05	6.4E+05
ANTIMONY				
ARSENIC				
BARIUM				
BENZENE	8.4E-02	1.4E-01	8.4E+01	2.8E+02
BENZO(a)ANTHRACENE				
BENZO(b)FLUORANTHENE				
BENZO(k)FLUORANTHENE				
BENZO(g,h,i)PERYLENE				
BENZO(a)PYRENE				
BERYLLIUM				
BIPHENYL, 1,1-	3.7E+01	5.1E+01	3.7E+04	1.0E+05
BIS(2-CHLOROETHYL)ETHER	3.4E-03	5.8E-03	3.4E+00	1.2E+01
BIS(2-CHLOROISOPROPYL)ETHER	2.4E-01	4.1E-01	2.4E+02	8.2E+02
BIS(2-ETHYLHEXYL)PHTHALATE				
BORON				
BROMODICHLOROMETHANE	6.6E-02	1.1E-01	6.6E+01	2.2E+02
BROMOFORM				
BROMOMETHANE	1.0E+00	1.4E+00	1.0E+03	2.9E+03
CADMIUM				
CARBON TETRACHLORIDE	5.8E-02	9.7E-02	5.8E+01	1.9E+02
CHLORDANE				
CHLOROANILINE, p-				
CHLOROBENZENE	1.3E+01	1.8E+01	1.3E+04	3.5E+04
CHLOROETHANE	2.9E+00	4.9E+00	2.9E+03	9.9E+03
CHLOROFORM	4.6E-01	7.7E-01	4.6E+02	1.5E+03
CHLOROMETHANE	1.4E+00	2.3E+00	1.4E+03	4.5E+03
CHLOROPHENOL, 2-	3.8E+00	5.3E+00	3.8E+03	1.1E+04
CHROMIUM (Total)				
CHROMIUM III				
CHROMIUM VI				
CHRYSENE				
COBALT				
COPPER				
CYANIDE (Free)				
DIBENZO(a,h)ANTHTRACENE				
DIBROMOCHLOROMETHANE	9.0E-02	1.5E-01	9.0E+01	3.0E+02
1,2-DIBROMO-3-CHLOROPROPANE	1.2E-03	2.0E-03	1.2E+00	4.1E+00
DIBROMOETHANE, 1,2-	3.4E-02	5.8E-02	3.4E+01	1.2E+02

TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Indoor Air and Soil Gas

CHEMICAL PARAMETER	INDOOR AIR SCREENING LEVELS		[2]SHALLOW SOIL GAS SCREENING LEVELS	
	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)
DICHLOROBENZENE, 1,2-	4.2E+01	5.8E+01	4.2E+04	1.2E+05
DICHLOROBENZENE, 1,3-	6.7E-01	9.3E-01	6.7E+02	1.9E+03
DICHLOROBENZENE, 1,4-	2.2E-01	3.7E-01	2.2E+02	7.4E+02
DICHLOROBENZIDINE, 3,3-				
DICHLORODIPHENYLDICHLOROETHANE (DDD)				
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)				
DICHLORODIPHENYLTRICHLOROETHANE (DDT)				
DICHLOROETHANE, 1,1-	1.5E+00	2.6E+00	1.5E+03	5.1E+03
DICHLOROETHANE, 1,2-	1.2E-01	1.9E-01	1.2E+02	3.9E+02
DICHLOROETHYLENE, 1,1-	4.2E+01	5.8E+01	4.2E+04	1.2E+05
DICHLOROETHYLENE, Cis 1,2-	7.3E+00	1.0E+01	7.3E+03	2.0E+04
DICHLOROETHYLENE, Trans 1,2-	1.5E+01	2.0E+01	1.5E+04	4.1E+04
DICHLOROPHENOL, 2,4-				
DICHLOROPROPANE, 1,2-	2.4E-01	4.1E-01	2.4E+02	8.2E+02
DICHLOROPROPENE, 1,3-	1.5E-01	2.6E-01	1.5E+02	5.1E+02
DIELDRIN				
DIETHYLPHTHALATE				
DIMETHYLPHTHALATE				
DIMETHYLPHENOL, 2,4-	1.5E+01	2.0E+01	1.5E+04	4.1E+04
DINITROPHENOL, 2,4-				
DINITROTOLUENE, 2,4-				
1,4 DIOXANE				
DIOXIN (2,3,7,8-TCDD)				
ENDOSULFAN				
ENDRIN				
ETHYLBENZENE	2.2E+00	3.7E+00	2.2E+03	7.4E+03
FLUORANTHENE				
FLUORENE	2.9E+01	4.1E+01	2.9E+04	8.2E+04
HEPTACHLOR				
HEPTACHLOR EPOXIDE				
HEXACHLOROBENZENE				
HEXACHLOROBUTADIENE				
HEXACHLOROCYCLOHEXANE (gamma) LINDANE				
HEXACHLOROETHANE				
INDENO(1,2,3-cd)PYRENE				
LEAD				
MERCURY				
METHOXYCHLOR				
METHYLENE CHLORIDE	2.4E+00	4.1E+00	2.4E+03	8.2E+03
METHYL ETHYL KETONE	2.1E+02	2.9E+02	2.1E+05	5.8E+05
METHYL ISOBUTYL KETONE	1.7E+01	2.4E+01	1.7E+04	4.7E+04
METHYL MERCURY				
METHYLNAPHTHALENE (total 1- & 2-)	2.9E+01	4.1E+01	2.9E+04	8.2E+04

TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Indoor Air and Soil Gas

	INDOOR AIR SCREENING LEVELS		[2]SHALLOW SOIL GAS SCREENING LEVELS	
CHEMICAL PARAMETER	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)
METHYL TERT BUTYL ETHER	9.4E+00	1.6E+01	9.4E+03	3.1E+04
MOLYBDENUM				
NAPHTHALENE	6.3E-01	8.8E-01	6.3E+02	1.8E+03
NICKEL				
PENTACHLOROPHENOL				
PERCHLORATE				
PHENANTHRENE	2.9E+01	4.1E+01	2.9E+04	8.2E+04
PHENOL				
POLYCHLORINATED BIPHENYLS (PCBs)				
PYRENE	2.3E+01	3.2E+01	2.3E+04	6.4E+04
SELENIUM				
SILVER				
STYRENE	2.1E+02	2.9E+02	2.1E+05	5.8E+05
tert-BUTYL ALCOHOL	2.8E+00	4.8E+00	2.8E+03	9.5E+03
TETRACHLOROETHANE, 1,1,1,2-	3.3E-01	5.5E-01	3.3E+02	1.1E+03
TETRACHLOROETHANE, 1,1,2,2-	4.2E-02	7.0E-02	4.2E+01	1.4E+02
TETRACHLOROETHYLENE	4.1E-01	6.9E-01	4.1E+02	1.4E+03
THALLIUM				
TOLUENE	8.3E+01	1.2E+02	8.3E+04	2.3E+05
TOXAPHENE				
TPH (gasolines)	1.0E+01	1.5E+01	1.0E+04	2.9E+04
TPH (middle distillates)	1.0E+01	1.5E+01	1.0E+04	2.9E+04
TPH (residual fuels)				
TRICHLOROBENZENE, 1,2,4-	4.2E+01	5.8E+01	4.2E+04	1.2E+05
TRICHLOROETHANE, 1,1,1-	4.6E+01	6.4E+01	4.6E+04	1.3E+05
TRICHLOROETHANE, 1,1,2-	1.5E-01	2.6E-01	1.5E+02	5.1E+02
TRICHLOROETHYLENE	1.2E+00	2.0E+00	1.2E+03	4.1E+03
TRICHLOROPHENOL, 2,4,5-	7.3E+01	1.0E+02	7.3E+04	2.0E+05
TRICHLOROPHENOL, 2,4,6-				
VANADIUM				
VINYL CHLORIDE	3.1E-02	5.2E-02	3.1E+01	1.0E+02
XYLENES	2.1E+01	2.9E+01	2.1E+04	5.8E+04
ZINC				

TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Indoor Air and Soil Gas

	INDOOR AIR SCREENING LEVELS		[2]SHALLOW SOIL GAS SCREENING LEVELS	
CHEMICAL PARAMETER	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not apploicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable	not applicable

Notes:

1. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
2. Soil Gas: Screening levels based on soil gas data collected less than 1.5 meters (five feet) below a building foundation or the ground surface. Intended for evaluation of potential indoor-air impacts.

Soil gas data should be collected and evaluated at all sites with significant areas of VOC-impacted soil. Screening levels also apply to areas over of impacted groundwater.

Source of soil ESLs: Refer to Tables E-2 and E-3 in Appendix 1.

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE F: SURFACE WATER

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS		
	[1]Freshwater (ug/L)	[2]Marine (ug/L)	[3]Estuarine (ug/L)
ACENAPHTHENE	2.0E+01	2.0E+01	2.0E+01
ACENAPHTHYLENE	3.0E+01	3.0E+01	3.0E+01
ACETONE	7.0E+02	1.5E+03	1.5E+03
ALDRIN	1.4E-04	1.4E-04	1.4E-04
ANTHRACENE	7.3E-01	7.3E-01	7.3E-01
ANTIMONY	6.0E+00	5.0E+02	5.0E+02
ARSENIC	1.4E-01	1.4E-01	1.4E-01
BARIUM	1.0E+03	1.0E+03	1.0E+03
BENZENE	1.0E+00	7.1E+01	7.1E+01
BENZO(a)ANTHRACENE	2.7E-02	2.7E-02	2.7E-02
BENZO(b)FLUORANTHENE	2.9E-02	2.9E-02	2.9E-02
BENZO(k)FLUORANTHENE	2.9E-02	4.9E-02	4.9E-02
BENZO(g,h,i)PERYLENE	1.0E-01	1.0E-01	1.0E-01
BENZO(a)PYRENE	1.4E-02	1.4E-02	1.4E-02
BERYLLIUM	2.7E+00	2.7E+00	2.7E+00
BIPHENYL, 1,1-	5.0E-01	5.0E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.4E-02	1.4E+00	1.4E+00
BIS(2-CHLOROISOPROPYL)ETHER	5.0E-01	6.1E+01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	4.0E+00	5.9E+00	5.9E+00
BORON	1.6E+00	1.6E+00	1.6E+00
BROMODICHLOROMETHANE	1.0E+02	3.2E+03	3.2E+03
BROMOFORM	1.0E+02	3.6E+02	3.6E+02
BROMOMETHANE	9.8E+00	3.2E+03	3.2E+03
CADMIUM	2.2E+00	9.3E+00	9.3E+00
CARBON TETRACHLORIDE	5.0E-01	4.4E+00	4.4E+00
CHLORDANE	5.9E-04	5.9E-04	5.9E-04
CHLOROANILINE, p-	5.0E+00	5.0E+00	5.0E+00
CHLOROBENZENE	2.5E+01	5.0E+01	5.0E+01
CHLOROETHANE	1.2E+01	1.2E+01	1.2E+01
CHLOROFORM	1.0E+02	4.7E+02	4.7E+02
CHLOROMETHANE	2.7E+00	3.2E+03	3.2E+03
CHLOROPHENOL, 2-	1.8E-01	1.8E-01	1.8E-01
CHROMIUM (Total)	5.0E+01	1.8E+02	1.8E+02
CHROMIUM III	1.8E+02	1.8E+02	1.8E+02
CHROMIUM VI	1.1E+01	5.0E+01	5.0E+01
CHRYSENE	4.9E-02	4.9E-02	4.9E-02
COBALT	3.0E+00	3.0E+00	3.0E+00
COPPER	9.0E+00	3.1E+00	3.1E+00
CYANIDE (Free)	5.2E+00	1.0E+00	1.0E+00
DIBENZO(a,h)ANTHTRACENE	8.5E-03	4.9E-02	4.9E-02
DIBROMOCHLOROMETHANE	4.6E+01	4.6E+01	4.6E+01
1,2-DIBROMO-3-CHLOROPROPANE	2.0E-01	2.0E-01	2.0E-01
DIBROMOETHANE, 1,2-	5.0E-02	1.4E+03	1.4E+03
DICHLOROBENZENE, 1,2-	1.0E+01	1.0E+01	1.0E+01
DICHLOROBENZENE, 1,3-	6.3E+00	6.5E+01	6.5E+01

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

	SURFACE WATER SCREENING LEVELS		
CHEMICAL PARAMETER	[1]Freshwater (ug/L)	[2]Marine (ug/L)	[3]Estuarine (ug/L)
DICHLOROBENZENE, 1,4-	5.0E+00	1.1E+01	1.1E+01
DICHLOROBENZIDINE, 3,3-	2.9E-02	7.7E-02	7.7E-02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	8.4E-04	8.4E-04	8.4E-04
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	5.9E-04	5.9E-04	5.9E-04
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	5.9E-04	5.9E-04	5.9E-04
DICHLOROETHANE, 1,1-	5.0E+00	4.7E+01	4.7E+01
DICHLOROETHANE, 1,2-	5.0E-01	9.9E+01	9.9E+01
DICHLOROETHYLENE, 1,1-	3.2E+00	3.2E+00	3.2E+00
DICHLOROETHYLENE, Cis 1,2-	6.0E+00	5.9E+02	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	1.0E+01	2.6E+02	2.6E+02
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	5.0E+00	1.0E+01	1.0E+01
DICHLOROPROPENE, 1,3-	5.0E-01	1.2E+02	1.2E+02
DIELDRIN	2.2E-03	1.9E-03	1.9E-03
DIETHYLPHTHALATE	1.5E+00	1.7E+00	1.7E+00
DIMETHYLPHTHALATE	1.5E+00	1.7E+00	1.7E+00
DIMETHYLPHENOL, 2,4-	1.0E+02	1.1E+02	1.1E+02
DINITROPHENOL, 2,4-	1.4E+01	7.5E+01	7.5E+01
DINITROTOLUENE, 2,4-	1.1E-01	9.1E+00	9.1E+00
1,4 DIOXANE	3.0E+00	5.0E+04	5.0E+04
DIOXIN (2,3,7,8-TCDD)	1.4E-08	1.4E-08	1.4E-08
ENDOSULFAN	5.6E-02	8.7E-03	8.7E-03
ENDRIN	3.6E-02	2.3E-03	2.3E-03
ETHYLBENZENE	3.0E+01	3.0E+01	3.0E+01
FLUORANTHENE	8.1E+00	8.0E+00	8.0E+00
FLUORENE	3.9E+00	3.9E+00	3.9E+00
HEPTACHLOR	2.1E-04	2.1E-04	2.1E-04
HEPTACHLOR EPOXIDE	1.1E-04	1.1E-04	1.1E-04
HEXACHLOROBENZENE	7.7E-04	7.7E-04	7.7E-04
HEXACHLOROBUTADIENE	2.1E-01	4.7E+00	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	6.3E-02	6.3E-02	6.3E-02
HEXACHLOROETHANE	7.0E-01	8.9E+00	8.9E+00
INDENO(1,2,3-cd)PYRENE	2.9E-02	2.9E-02	2.9E-02
LEAD	2.5E+00	8.1E+00	8.1E+00
MERCURY	5.1E-02	2.5E-02	2.5E-02
METHOXYCHLOR	1.9E-02	1.9E-02	1.9E-02
METHYLENE CHLORIDE	5.0E+00	1.6E+03	1.6E+03
METHYL ETHYL KETONE	4.2E+03	8.4E+03	8.4E+03
METHYL ISOBUTYL KETONE	1.2E+02	1.7E+02	1.7E+02
METHYL MERCURY	3.0E-03	3.0E-03	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.1E+00	2.1E+00	2.1E+00
METHYL TERT BUTYL ETHER	5.0E+00	1.8E+02	1.8E+02
MOLYBDENUM	3.5E+01	2.4E+02	2.4E+02
NAPHTHALENE	2.1E+01	2.1E+01	2.1E+01
NICKEL	5.2E+01	8.2E+00	8.2E+00

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

	SURFACE WATER SCREENING LEVELS		
CHEMICAL PARAMETER	[1]Freshwater (ug/L)	[2]Marine (ug/L)	[3]Estuarine (ug/L)
PENTACHLOROPHENOL	1.0E+00	7.9E+00	7.9E+00
PERCHLORATE	7.0E-01	6.0E+02	6.0E+02
PHENANTHRENE	6.3E+00	4.6E+00	4.6E+00
PHENOL	5.0E+00	1.3E+03	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	1.7E-04	1.7E-04	1.7E-04
PYRENE	2.0E+00	2.0E+00	2.0E+00
SELENIUM	5.0E+00	7.1E+01	7.1E+01
SILVER	3.4E-01	1.9E-01	1.9E-01
STYRENE	1.0E+01	1.1E+01	1.1E+01
tert-BUTYL ALCOHOL	1.2E+01	1.8E+04	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	1.3E+00	9.3E+02	9.3E+02
TETRACHLOROETHANE, 1,1,2,2-	1.0E+00	1.1E+01	1.1E+01
TETRACHLOROETHYLENE	5.0E+00	8.9E+00	8.9E+00
THALLIUM	2.0E+00	6.3E+00	6.3E+00
TOLUENE	4.0E+01	4.0E+01	4.0E+01
TOXAPHENE	2.0E-04	2.0E-04	2.0E-04
TPH (gasolines)	1.0E+02	3.7E+03	3.7E+03
TPH (middle distillates)	1.0E+02	6.4E+02	6.4E+02
TPH (residual fuels)	1.0E+02	6.4E+02	6.4E+02
TRICHLOROBENZENE, 1,2,4-	2.5E+01	6.5E+01	6.5E+01
TRICHLOROETHANE, 1,1,1-	6.2E+01	6.2E+01	6.2E+01
TRICHLOROETHANE, 1,1,2-	5.0E+00	4.2E+01	4.2E+01
TRICHLOROETHYLENE	5.0E+00	8.1E+01	8.1E+01
TRICHLOROPHENOL, 2,4,5-	6.3E+01	1.1E+01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	5.0E-01	6.5E+00	6.5E+00
VANADIUM	1.5E+01	1.9E+01	1.9E+01
VINYL CHLORIDE	5.0E-01	5.3E+02	5.3E+02
XYLENES	1.3E+01	1.3E+01	1.3E+01
ZINC	1.2E+02	8.1E+01	8.1E+01

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS		
	[1]Freshwater (ug/L)	[2]Marine (ug/L)	[3]Estuarine (ug/L)
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable

Notes:

1. Source of Freshwater ESLs: Refer to Appendix 1, Table F-2a
2. Source of Marine ESLs: Refer to Appendix 1, Table F-2b.
3. Source of Estuarine ESLs: Refer to Appendix 1, Table F-2c.

Surface water screening levels lowest of drinking water goal (freshwater only), chronic aquatic habitat goal, goal to address bioaccumulation in aquatic organisms and subsequent consumption by humans, and general nuisance goal (odors, etc.). Refer to Section 2.7 of text for discussion.

Estuarine screening levels lowest of freshwater and marine screening levels.

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Section 2.2 and Appendix 1, Chapter 5.